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ABSTRACT

This intensive state-of-the-arts review of rice postharvest losses, occurring during threshing, drying, parboiling, and milling, provides a critical assessment of what, where, and why losses occur; what is being done to combat such losses; and specific recommendations about where future international assistance efforts might best be focused to maximize loss reductions and the conservation of rice already produced. Previous studies have clearly determined that the majority of rice losses occur when harvested rough rice is being transformed into edible white rice. Thus, the authors of this review have focused on this period and include recommendations on new or improved equipment or processes that could be developed to improve efficiencies and reduce losses. The publication contains a selected bibliography of more than 200 publications in three categories: Bibliographies and Information Services, Serials and Catalogues, and Books and Articles.

KEYWORDS: Rice postharvest losses, rice threshing, rice drying, rice milling, rice parboiling.

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RICE POSTHARVEST LOSSES IN DEVELOPING COUNTRIES

Part 1

A 1978 Survey of Rice Postharvest Losses During Threshing, Drying, Parboiling and Milling, and the Potential for Reducing Such Losses in Developing Countries[1]

By R. M. Saunders, A. P. Mossman, T. Wasserman and E. C. Beagle[2]

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PROJECT SUMMARY

In response to efforts around the world to increase food supplies through decreasing food losses, the Agency for International Development (AID) initiated this study into updating knowledge on rice postharvest practices in developing countries. An intensive state-of-the-arts review of postharvest losses provides AID with a critical assessment of what, where, and why losses occur, what is being done to combat such losses, and specific recommendations where use of future assistance funds from AID and others can be placed most effectively. The National Academy of Science study (4)[1] and others clearly had determined that the majority of losses occurred during the system involved in transforming harvested rough rice into edible white rice. Thus the state-of-the-arts review was to focus on this system and include recommendations on new or improved equipment or processes that could be developed to improve efficiencies in this system and to reduce losses.

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The authors thank W. Smith Greig, Office of Agriculture, Bureau for Development Support, AID, Washington, for his unfailing enthusiasm and optimism and for providing a working environment in which the project could be carried out efficiently and successfully. No less emphatically, the authors extend their thanks to the hundreds around the world who, aware of the potential impact reducing rice losses could have on the welfare of mankind, gave unselfishly of their time and knowledge to meet the project ojectives.

I. INTRODUCTION

The information contained in this report is based on data obtained from interviews and visits with interested workers, institutions, and companies during worldwide field investigations during 1978. While it represents knowledge obtained from organizations and personnel concerned with the technical problems, it is not possible for USDA to assume responsibility for statements contained herein. Reference to a company and/or product named by the authors is only for purposes of information and does not imply approval or recommendation of the process or product to the exclusion of others which may also be applicable or suitable.

The world food situation continues to affect both developed and developing countries. During an era when the impact of the Green Revolution has been both demonstrated and realized, per capita food availability has not been measurably altered. Undernutrition and malnutrition are still major health problems in economically developing countries (1,2).[1]

In 1973, the U. S. Congress amended the Foreign Assistance Act of 1961 and specified that United States economic development assistance be concentrated in three principal (though interdependent) areas--food and nutrition, population and health, and education and human resources development. Congress also

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[1] Numbers in parentheses refer to the list of references beginning on p. 146.

intended that such assistance should be directed toward the poor majority of the populations in developing countries. This mandate is contained in Section 102-106 of the Foreign Assistance Act. In 1975, Congress added Section 107 which specified that certain funds should be earmarked for "an expanded and coordinated effort to promote the development and dissemination of technologies appropriated for developing countries" (to be carried out by USAID).

Resolution No. 3362(S-VII) of the Seventh Special Session of the General Assembly of the United Nations stated that "postharvest food losses in developing countries should be reduced by 50% by the year 1985." In response to this mandate, in 1977, an FAO Action Program for the Prevention of Food Losses was established (3). The basic purpose is to assist developing countries in their effort to identify the food losses which occur throughout the postharvest system and to plan and implement national food loss reduction programs. Its first priority is to concentrate upon staple foods, including food grains. The second priority is to concentrate the actions towards benefitting the rural poor in developing countries, that is, small farmers, villagers, and small-scale processors.

Postharvest losses in food crops occurring during harvesting, threshing, drying, processing, storage, transportation, etc. have been estimated to claim between 30 and 40% of all food crops in developing countries (4). Experts have predicted that the most efficient way to increase food availability is to control the losses occurring between the field and the consumer, i.e., "it is much more economical to save what is already produced" (5).

There is no staple food crop which more accurately reflects the problems which these national and international bodies have addressed than does rice. Rice currently accounts for as much as 75% of the total caloric intake of the 1.9 billion people living in Africa and Latin America (6). In numerous countries the per capita consumption of rice represents a caloric intake substantially above these average values; for example, Bangladesh and Indonesia in Asia, Sierra Leone and Liberia in West Africa, and areas of Bolivia and Colombia in Latin America (7). It is noteworthy that in those regions heavily dependent upon rice as a food, protein-caloric malnutrition is prevalent (8).

Annual rice production in the developing countries can be calculated to be about 200 MMT. Even though rice production increased in the developing countries by about 21% during the period 1968 and 1976, per capita consumption was not significantly altered (7). Indeed, it has been estimated that by 1985 worldwide rice production must increase by about 30% to simply maintain current (though inadequate) levels of consumption (9).

The fact that rice would benefit widely from programs directed at reduction of postharvest losses is recognized widely. FAO has documented that rice postharvest losses are among the highest of the major crops grown in developing countries (10) and has called attention to the potential to be gained by reducing postharvest losses of rice (3). Rice is subjected to more handling and processing steps as it moves from the rice paddy or field to the consumer than other grain products in developing countries. Little mechanization exists in rice processing, and where it does, it is most often antiquated or makes use of poorly designed equipment. The lack of adequate processing equipment contributes significantly to postharvest losses in rice, which have

been estimated to be as high as 40% of total production (11,12; Table 1 and 2). The losses at various handling and processing steps are estimated in the table below.

Table 1

Estimates of Rice Postharvest Losses in the Philippines (Ref. 11)

Step	% Losses
Harvesting	1 - 3
Handling	2 - 7
Threshing	2 - 6
Drying	1 - 5
Storing	2 - 6
Milling	2 - 10

Using the current estimates of 200 MMT for paddy rice production in developing countries and the loss figures from Table 1, postharvest losses would range from 20-74 MMT. The mean value of 47 MMT would provide about 120 million people with sufficient food (2500 cal/cap/day) for one year. At prices of $200/MT, the monetary value of these losses ranges from $4 billion to $14.8 billion per year. At the current rate of production and mean losses, the 50% reduction in postharvest losses by 1985 as advocated by the United Nations would make available an additional 23.5 MT of rice. This is equivalent to the annual caloric requirement of 60 million people and at $200 per ton would save approximately $4.7 billion per year. A mere 2% reduction in losses in the developing countries would provide 4 MMT of rice equivalent to the annual caloric requirement of 10 million people and valued at about $800 million per year.

As noted above, severe losses occur during harvesting, threshing, drying and milling of rice. Even some of the losses during rice storage are directly attributable to inadequate drying prior to storage. Since these losses are caused or aggravated by use of inadequate processing equipment or, in most cases, a lack of small-scale equipment, the most efficacious approach to reducing such losses would be to improve small and intermediate scale technology.

This situation is recognized and has been discussed from philosophical and technological viewpoints in a Department of State Seminar in Foreign Policy (13), and by FAO (3,5), the International Rice Research Institute (IRRI) (14), and others familiar with the rice situation (11,15,16,17). The increased production resulting from the introduction of new rice varieties has stimulated the need for technologies that are simple and inexpensive, yet faster and more efficient than traditional technologies. Thus, the possibility of two or three rice crops per year has increased the need for faster and more efficient land preparation, fertilization, harvesting and postharvest processing.

The problem of obtaining more rice in the developing countries has been dealt with in varying degrees by IRRI. Many years have been devoted to developing small-scale mechanized farm equipment with some degree of success. The effort

Table 2

Reported Losses of Rice within the Postharvest System (Ref. 3)

Region and Country	Total Percent Weight Loss	Remarks
West Africa	6 - 24	Drying 1-2; on-farm storage 2-10; parboiling 1-2; milling 2-10
Sierra Leone	10	
Uganda	11	
Rwanda	9	
Sudan	17	Central storage
Egypt	2.5	
Bangladesh	7	
India	6	Unspecified storage
	3 - 5.5	Improved traditional storage
Indonesia	6 - 17	Drying 2; storage 2-5
Malaysia	17 - 25	Central storage 6; threshing 5-13;
	c.13	Drying 2; on-farm storage 5; handling 6
Nepal	4 - 22	On-farm 3-4; on-farm storage 15; central storage 1-3
Pakistan	7	Unspecified storage 5
	2 - 6	Unspecified storage 2
	5 - 10	Unspecified storage 5-10
Philippines	9 - 34	Drying 1-5; unspecified storage 2-6; threshing 2-6
	up to 30	Malaysia workshop
	3 - 10	Handling
Sri Lanka	13 - 40	Drying 1-5; central storage 6.5; threshing 2-6
	6 - 18	Drying 1-3; on-farm storage 2-6; milling 2-6; parboiling 1-3
Thailand	8 - 14	On-farm storage 1.5-3.5; central storage 1.5-3.5
	12 - 25	On-farm storage 2-15; handling 10
Belize	20 - 30	On-farm storage
Bolivia	16	On-farm 2; drying 5; unspecified storage 7
Brazil	1 - 30	Unspecified storage 1-30
Dominican Republic	6.5	On-farm storage 3; central storage 0.3

has been concentrated upon the agronomic aspects of growing more rice, i.e., farm-level applications, rather than reduction of losses. Small-scale hardware projects in various stages of development include field tractors, tillers, seeders, weeders, and fertilizer applicators. At the postharvest level, the IRRI threshers show limited though increasing acceptance. Even though IRRI has been virtually a pioneer in developing appropriate technology for rice cultivation in Asia, their program has not been without some criticism (13).

While IRRI has carried out work on developing new village-level drying, parboiling, and milling systems and have stated that "it is essential that a centralized effort be made to provide basic research and development capabilities in the field of postharvest (rice) technology..." (14), they have stated also that they are reducing and may discontinue their efforts on postharvest processing mechanization developments in order to concentrate fully on production phases (communication to WRRC/USAID team, July 1978).

In agreement with the Western Regional Research Center (WRRC) of the United States Department of Agriculture, AID financed this State-of-the-Arts review of techniques and equipment used in threshing, drying, milling, and parboiling phases of the rice food chain in developing countries. The study carried out between May 1978 and February 1979, comprised the following:

1. A comprehensive overview of village/subsistence and quasi-commercial level state-of-the-art rice processing in LDCs.

2. A realistic approach to the individual local possibilities of system development and/or modification.

3. Determination of methods and equipment presently available for improving rice threshing, drying, parboiling and milling at each level of requirement.

    a. single small subsistence farmer.
    b. single small commercial farmer.
    c. single medium/large commercial farmer.
    d. cooperative groups at village level.
    e. small entrepreneurs who buy paddy from farmer and process for local trade.
    f. custom operators who do individual threshing, drying, parboiling and milling on a toll basis.
    g. small-scale commercial operations.

4. A practical assessment of current systems and hardware while searching for ones with advantages that have not been fully exploited.

5. A review of existing hardware with a view toward the acquisition and further development or improvement of worthy items.

6. A proper assessment of losses at the various stages of handling and processing with a statistical study of the combination possibilities and the definitive areas of loss.

7. An analysis of the specific potential for developing new or improved rice threshing, drying, parboiling and milling equipment.

8. An assessment of realizable improvement that could be attained with introduction of the various changes proposed.

9. Recommendation of specific prototype developments for system designs and equipment that indicate possibility of improvement in their performance.

10. A socioeconomic approach to the adoption of new systems and/or hardware.

11. An evaluation of representative and promising items of equipment at the Western Regional Research Center.

12. Coordination of similar programs under way or to be instituted by other agencies and institutions.

During 1978, one or more team members appraised rice processing facilities at the farm and village levels, discussed postharvest rice problems and programs with university, government, institutional, commercial and consultant personnel, and visited numerous rice machinery manufacturers and some commercial banks in the following countries: Japan, Korea, Taiwan, Philippines, India, Indonesia, Sri Lanka, Thailand, Colombia, Bolivia, Peru, Ecuador, Sierra Leone, Liberia and England. Discussions were held also with FAO (Italy) and UNIDO (Austria) on their current efforts in the field.

These interviews and accumulated documents represent the most comprehensive and up-to-date compilation of knowledge and practices in the area of postharvest processing of rice in developing countries. The observations are documented in this report.

The food supply situation has marginally improved in some developing countries in recent years. This has resulted somewhat from improved supplies of essential inputs, national agricultural policies and incentives. Weather has played a most significant role in making such increases possible, therefore, a brief spell on an improved situation should not lead to complacency, particularly in countries where production has not been affected by unfavorable weather conditions. Rather, such relatively favorable situations must be utilized in preparation for the future. Stategies may differ from country to country, but the central theme must be to ensure a good harvest and increased food production and its stabilization.

Despite the recent general improvement in food production and stocks, the rate of growth of food grain production in many countries remains below that required to meet the rising demand due to population and income growths. Unless production is accelerated, dependence on food imports and food aid would not only continue but rise in the future. Measures adopted to increase the production of food and to prevent losses of the produce along with properly managed stocks are the basic requirements of a national food security system. While the primary responsibility to increase food production, avoid losses and maintain food stocks should lie with a country, the need for increased flow of external resources for agricultural development and expansion of facilities has been more apparent than ever before.

The improvement of postharvest technology is often discussed, but in almost every case, the viewpoint is confined to one of reduction of grain loss. The one factor not normally considered is the existence of production deterrents. It should be obvious that this attention to losses is not the primary method of improving the farmers' lot. Upon close examination, it would seem that the most improvement would come from the removal of constraints to production--which in many cases are looked at as losses. The extent and commonality of such deterrents are usually ignored or beyond the perception of the worker.

In many developing countries, only about 10-30 percent of the total food produced enters the regular marketing channels, and the remaining is retained with the producers who are mostly small farmers. The magnitude and complexity of the system vary from country to country. Where subsistence farming holds sway, it is only a question of harvesting, storing, and processing the crop on the farm itself. But there is an obvious need to produce more than the individual farmer's needs, which will give him a marketable surplus. But as long as he remains a subsistence farmer in his own eyes and refuses to embrace a commerical philosophy, he will remain at the depths of the subsistence economy.

The improvement in postharvesting technology will have a much greater socio-economic implication than simple reduction of grain loss, which will result as a natural consequence of the development of rural society and of the marketing system in which postharvesting technology plays an important role. The objective of national agricultural development programs is not just to increase production but to make food available to more people. One of the important means of doing this is through proper preservation and distribution of the produce after harvest.

Since a fair share of the agricultural food production is lost during and after harvest--before reaching the consumer--a widespread interest and concern about such losses and ways and means of combating these losses have emerged in recent years. With the cooperation of FAO and other agencies, this has led to the development of many national programs. These include setting up of proper warehouses, maintenance of adequate stocks, appropriate measures in sanitation, infestation control and better processing facilities. However, there is still a need to develop more effective activities for the reduction of food losses. These should be expanded to cover the whole spectrum of the post-tharvest system, thus increasing the chances of more food becoming available to more people.

It is doubtful whether improved postharvesting technology can be encouraged only from the viewpoint of reduction of grain loss if it is not coupled with the interest of farmers and other people concerned. It may appear that reduction of grain loss will benefit them without any doubt, but it does not necessarily follow that the technology required for the purpose will be accepted by them. If there exist other investments which have higher cost-benefit ratios or other items which can give them better results for the same amount of money, they are sure to choose these in place of the said technology. Many unsuccessful attempts to introduce new technology for the postharvest process reflect such situations, although the improvements are said to be most economical.

It has always seemed that, for reasons more evident to the psychologist than to food and agricultural scientists, investment in increased agricultural production--the creation of high-yielding varieties and multiple-cropping systems--appears an infinitely more attractive venture than a rigorous effort to reduce the wastage of crops after they are harvested.

The most serious handicap to improvement in rice postharvest processing is the fact that the quality of paddy is not assessed objectively or reflected proportionally in the market price. This reduces the incentives to use improved equipment and techniques which are effective not only in the reduction of grain loss but also in the improvement of grain quality. In order to insure the existence of incentives, it is essential to introduce an acceptable grading standard and inspection system and to provide the instruments required. Otherwise, it will be difficult to effect an improvement in the technical level of rice farmers, the organization of cooperatives, the upgrading of the socioeconomic conditions of farmers, and to achieve technical improvement of commercial rice mills, all actions which directly and indirectly reduce grain losses.

Many benefits flow from the existence of the orderly, efficient, postharvest system. It creates the climate of confidence which is required to convince the subsistence farmer to produce paddy beyond his own requirements and to embrace the concept of commercial farming. Many of the advantages of such improvements in production are lost unless matched by an equivalent improvement in a postharvest infrastructure that makes possible the delivery of the food crops to the consumers in the manner which they desire. But through all this, the losses occur onward and collectively.

It must be understood that throughout this report references to and impace of storage, storage losses, pest control and related losses have been expressly bypassed because of the directed scope of investigation.

II. GENERAL DISCUSSION

Within each country, the major phases of the rice processing sequence which were reviewed are discussed separately. Within each phase, several levels of technology and social complexity are usually included. The many specific items, including policies, research, country practices and so forth, have been developed into the following format:

Country

Phase of processing (included under each country)

A General
B Threshing
C Drying
D Parboiling
E Milling
F Other

Level of complexity (included under each Phase heading)

A Subsistence
B Village
C Quasi-commercial
D Export (limited treatment)

Although the terms used in the format are somewhat self-explanatory, some description of the phases and levels from the authors' perspective is in order. By "phases of processing" are meant the individual treatments which the rice undergoes during the normal processing sequence. The phases which were studied comprise threshing, drying, parboiling and milling only. Surveys of harvesting and storage were not carried out because (1) the review was directed by AID to focus primarily on mechanical aspects; (2) storage technology is reasonably well developed and can be expected to reduce losses by application alone; (3) rice storage problems are very often caused by inadequacies during prior phases, particularly, inadequate drying. The authors realistically concede that a large amount of rice is lost during storage, and for optimum reductions in rice postharvest losses, correct storage facilities should be available. The authors also concede that losses accrue because of inadequacies during harvesting. Nevertheless, this report focuses on only those aspects noted earlier, which together account for the majority of rice losses.

The levels of technology chosen are somewhat arbitrary and are not set apart as separate subsections. By "level" is meant the degree of technological and social complexity at which the particular farmer or processor is operating. Four levels were easily distinguished: (1) subsistence, (2) village, (3) quasi-commercial, and (4) export.

The characteristics associated with each level are as follows:

(1) The simple subsistence or homestead level is characterized by production for the purpose of consumption, usually on an individual or family basis, with no capital investment in machinery. In the situations where land holdings are small and subsistence farming is prevalent, the general economic level of all is low, labor is extremely cheap, and so there exists a level below the subsistence farmer, that of the farm worker who is paid in handfuls of rice for his work. However, for our discussion, we have considered the subsistence farm worker and subsistence farmer as comprising the same level.

(2) The village level is exemplified by the man who owns a small mill (one machine) upon which he mills individual bags of rice brought by farmers or others for a fee, often consisting of rice or rice milling by-products. This is the first level at which sophisticated mechanical improvements can be used because the capital required is either directly (i.e. a cooperative) or indirectly (i.e. fees or levies) supported by a group. On the farm, custom harvest groups using threshers and other machines work for a fee, most often, rice. It must be emphasized that these are small operations at this level, the machines are small and the people are still subsistence oriented with the commercial aspects, such as fees, added only to allow the machines to be supported by a larger group.

(3) The quasi-commercial level is the next step. The farmer, however small, is interested in selling his crop, though he may retain some for his own use. The miller may also be small, having very few machines in his processing line, but he has a capital investment, a schedule of fees, marketing, occasionally a drying operation of some sort, he may trade, and most of all, he thinks and acts commercially with the same purpose and problems as the larger operator. Although the range of size of operations is greatest at this level, the technological need and approach to problems is similar throughout. It is at this level that nontechnological influences begin to contribute as much to the availability of food supply as technology.

(4) The export (sophisticated commercial) level differs from the quasi-commercial level mostly in the scope of the operations, in the quality of the rice, and in the attitude and purpose of the managers of the operations. The operator now competes for financial gain, investing money, technology, and above all, care, to obtain increased financial return. Although there are quasi-commercial operations which are larger than some export level ones, the difference in the operation itself and the product make this highest level strikingly different no matter the size. While the quasi-commercial operation is limited in scope, limited resources are used to serve a limited market, and many factors which are missing at this level are superfluous to success, the export operation is not limited, and the export operator seeks wide markets. Whether the export operator actually sells his rice out of the country or domestically is of no importance because to be successful he competes in a market equivalent to a world market, produces rice of the desired quality (much of the rice in international trade is poor quality), transports, finances, and brings sufficient resources to handle all the complex problems possible. Technology is important to the export operator as are nontechnological factors, but the type of technology he needs is usually available in highly developed form and often he has the means of obtaining it. For this reason, we have not included this level in our study except where the techniques and lessons may also apply to the other three levels. For example, the successful export quality producer of today may have been a struggling domestic commercial or village operator in the past, and the problems he has overcome may be the very ones now facing other lower level operators elsewhere. Matching such problems and solutions has been one of the goals of this project.

Threshing

Threshing is the removal of the grain from the cut straw after harvest and is closely related to harvesting operations which include reaping, that is the cutting of the rice plant after maturity, and any operations between cutting and threshing. In capital intensive systems, reaping and threshing are accomplished in a single mobile machine. In less mechanized situations, the threshing operation is often done with a stationary machine placed in the field at harvest so that the stalks are reaped, gathered and transported a few yards to be threshed on site during the same working day. Also common is a more centrally located threshing operation serving harvesting operations in several surrounding fields. The rice is not always threshed immediately after harvest. If weather permits, the bundles of rice may be left in the fields to dry, or stored at home for weeks or months before threshing. More primitive methods of threshing include placing the rice with straw in a reasonably deep

pile on a cleared dry surface and running over it with with a tractor, or with animals, or striking the pile with a flail by hand. Single bundles can be beaten against a rack or drawn over a special threshing comb to remove the grains.

Because most of the rice produced in the developing areas is still threshed without mechanical threshers, virtually all of the varieties grown in these areas possess the genetic trait of easy release of the grains from the straw. Unfortunately, this trait, which is necessary to allow hand threshing, is also a source of losses since grains more easily drop off during harvest. All of the IRRI high yielding varieties are high shatter types. The term "shatter" refers only the the ease of release from straw and does not mean breakage of the grain. Shattering losses, actual breakage, and quality losses during this phase depend a great deal on the care with which the workers perform the operations. The less mechanized methods can be quite gentle if done properly and suffer mostly from lack of capacity which increases generally in proportion to the supplementary power used, from hand, to cattle, to tractor, to mechanical thresher.

Since the introduction of varieties which mature during the wet season, the problems of wet rice and wet ground have been superimposed on the other problems already present. Some of the traditional methods fail under these conditions contributing additional losses.

Not all threshers can handle wet material, and some designs do not allow transportation over wet fields. The wet season crop is usually a second crop so that while there is much less time available to harvest each crop, the second crop is especially difficult to harvest, thresh and dry at all, let alone quickly.

Drying

Rice if held above 22% will ferment, if held between 20 and 16% will mold quickly, and if held between 16 and 14% will mold after a period of time. The processes occur much more quickly in tropical areas. In warm, dry weather, the rice can usually be dried without artificial means either by exposure to the sun or to dry air (shade drying). The drying period can be longer even though the rice moisture content is high, since the moisture content at the surface of the rice is maintained at a low level. If the surface is not kept dry by sun, aeration, or some artificial means, the rice will spoil.

The problem of drying must be looked at from two completely different perspectives, both of them valid. The first focuses on the losses ~~which~~ by breakage during subsequent milling; this breakage is a consequence of too rapid drying. For example, rice dried continuously from about 22% to 13% in less than an hour may be expected to break up completely upon milling. Rapid moisture gain by dry rice, such as would occur during exposure of sundried rice to rain, results in similar breakage upon milling. The smaller brokens often find their way into the bran and hull streams of the mill and may constitute real losses. Poor drying technique can also cause loss of quality such as yellowing of the grains. Drying at moderate temperatures in stages with tempering (moisture equilibrium) periods between drying periods prevents such

milling losses. In sun drying, the rice is constantly turned. Natural air drying is usually slow enough, but the rice must be protected from the rain. Lodging or harsh field drying result in breakage.

The second perspective concerns the systems in which most of the brokens are included as food, no premium is give for better quality rice, and the major problem is prevention of outright spoilage of the rice during the wet season. The potential loss in this situation is much greater than above. Obviously, it is better to accept breakage, if necessary, to prevent the loss of the entire crop. In this latter situation, the lack of artificial driers of sufficient capacity near enough to the harvest is the usual problem because the harvested crop is wet, is there in great quantities, and there is insufficient sun or naturally dry air. A secondary but equally serious problem is the cost and lack of financial incentive to the farmer so that many of them will refuse artificial drying and chance spoilage by attempting natural drying using what sun and air there is available. In fact, artificial driers are usually found only at commercial mills. In any case, the type of drier and the drying routine is less important in this latter situation. The ability to save the crop depends more on drier availability, capacity, cost and fuel.

All of the drying methods can effectively dry the rice. Sun drying of the threshed rice requires warm sun, absence of rains, a drying yard or floor, and sufficient inexpensive labor to turn the rice constantly and gather it in at night. Shade drying is best done by placing unthreshed rice with the panicles inward, often on specially built racks, so that the straw shades and protects the rice grains. The arrangement must allow sufficient movement of air around the rice, and the air must be dry enough to be effective. The labor requirement is less and drying time longer than with sun drying. Both natural methods lose rice to predators, especially birds, but are nevertheless the most popular because of the minimal cost.

There are a great number of types of artificial driers, yet most share certain characteristics so that a terminology has developed to describe commonly seen features. The simplest in principle is the bin of rice through which ambient air is forced, usually entering the bottom and leaving from the top. This is called <u>deep bed</u> type of drier because the bed of rough rice is too deep (several feet) to be disturbed by the required force of air passing through it. In the alternative type, the air path through the rice is quite short, typically a foot or so. Since the most common designs have the rice flow downward in narrow columns with the air moving sideways through them, the term <u>column drier</u> is used more often than "shallow bed". The commercial column driers usually have the capability to heat the air, control the temperature, move the rice (e.g. recirculating drier) and sometimes to temper the rice between drying passes. An <u>LSU drier</u> is a column drier with a thicker bed but with alternating air intake, and exit pipes passing through the bed at frequent intervals to maintain the short air path. The term <u>flat bed drier</u> is usually used to describe driers with a shallow flat bed often two to six feet deep. However, the term has a particular significance when referring to village level processing of rice. Whereas the usual deep bed design resembles a storage structure, some small, shallow flat bed types, promoted in the Philippines and elsewhere for village scale batch drying of rice using heated air, have more of the characteristics usually associated with column driers. In fact, one variation using partitions to maintain identity of rice batches

actually is a static column drier. The use of other drier types in developing countries is limited and often experimental. However, rotary driers or kilns may be used in modern parboiling plants.

Fuel for artificial driers is an important consideration as is the driving power for the forced air. The blowers are most often run by small engines or, less often, by electricity. Burners using oil or natural gas are used to heat the air if necessary, but husk or wood burners are used in some places. Farmers who have straw but not husk could logically use it for fuel but burner design then becomes a problem. An additional problem for the farmer and, to a lesser extent, the miller and others is that in most developing countries rice drying does not pay for the person who does it, although the society as a whole benefits from the increase in quantity and quality of rice.

During the wet season, natural drying is often impossible and roads to the nearest mechanical drier are often difficult or impossible, so that spoilage of the whole crop is a very real danger. Because of these difficulties, many farmers refuse to plant a second rice crop and either plant another type of crop or none at all. The resulting loss of production does not show up in loss estimates but is a very real loss for the people who need the rice. The fact that some areas do multiple-crop rice successfully underlines this source of loss.

Milling

Milling consists of separating the paddy or rough rice from the dirt, stones, and other non-rice; removal of the husk; separation of the husks, dehusked brown rice and unhusked rice; removal of some or all of the bran layers from the brown rice; separation of the resulting white rice and bran; such additional polishing, sizing and coating steps as the market may require. The same steps used for raw rice are used for parboiled, although the parboiled kernel is harder necessitating minor differences in procedure.

The easiest way to mill is to carry out each of the several steps in sequence. In the case of a mechanical operation, a separate machine is required for each major step. Because of the high capital needed for a multimachine mill layout, the village level operation most often uses a single machine, producing two outputs, a semi-white rice, and a by-product consisting of ground husk, bran, ground rice, dirt and whatever else was put into the machine. Also somewhat less common at the village level are separate machines for the dehusking and for the bran removal with a screening device as a third component which is used for precleaning and for any milling separations which might be done. Usually, if capital resources and the market permit expansion at all, the village mill goes directly from the one machine to a small capacity multimachine layout.

In the case of hand milling, one of several devices can be used for husk removal. For example, a wooden bowl (mortar) may contain the paddy while a pole (pestle) rounded to match the bowl is repeatedly dropped into the rice. The friction of the rice grains against themselves dehusks and removes some bran. Frequent separation of the brown rice from the mixture assures that only the unhusked rough rice receives the blows from the pole, minimizing breakage. A flat woven basket is used for classifying the milled rice

materials by tossing the mixture into the air and catching it so that the lighter husk is blown away (winnowing), or shaking while held at an angle so that the paddy separates from the milled rice (gravity table). Where practical, hand milling is done in individual homes or at a central location shared by several families.

Mechanical milling is done at a mill in most countries although kitchen type rice mills are popular in Japanese homes. The larger village mills and the domestic commercial mills may also carry out threshing (rare), drying, parboiling and drying (in parboil areas), precleaning before drying, and such other operations that are profitable, as well as the milling. Storage and trading in rice and feeds is sometimes done by the larger millers.

The terminology commonly used in describing the various milling steps and machines is confusing. A brief description of the terms used in this report follows:

Precleaning: Removal of foreign material from the paddy, which is done by knowledgeable millers before drying, before parboiling and before milling to produce the best possible product and protect the equipment. A large variety of reels, sieves, and gravity separators are employed for this step. A special gravity table, called a stoner or destoner, is used to remove stones the same size as the rice. The cleaned rice is called rough rice, paddy, or palay.

Dehusking: Removal of husk or hull. Also called shelling, husking, and sometimes hulling. The machines which are called sheller, huskers, dehuskers or hullers include:

(a) Steel huller (also called Engelberg, Kiskisan): a ribbed steel cylinder rotating inside a steel screen, originally used to remove hulls from coffee beans (thus the word "huller"). The huller is the most common machine for one-pass combination dehusking and debranning. It can also be used as a separate sheller, or separate whitener (to remove bran). The use of a "huller" to remove bran is, unfortunately, confusing terminology.

(b) Disc sheller (also called underrunner): Two horizontal flat abrasive discs (vertical shaft) set close together, the top stationary, the bottom revolving, with the paddy entering the center, forced to move toward the rim by centrifugal force, and forced to open when the ends of the paddy grains catch between the discs. This machine requires reasonably dry paddy.

(c) Rubber roll sheller: Two metal rolls covered with rubber sheaths, run at differential speeds, catch the width of the rice, and strip away the husk. Can be used on damp paddy. Rubber rolls may wear quickly and are easily damaged by foreign material (e.g. stones).

(d) Centrifugal sheller: Paddy is thrown from the center by a revolving impeller against a rubber lined outside wall. The impact frees the

rice from the husk. There are various designs, both horizontal and vertical. Rice breakage can be a problem but mixed varieties are not, nor is damp rice.

(e) Apollo mill (also called Pin Kaeu or Thai horizontal abrasive mill): A horizontal steel cylinder covered with abrasive, revolving in a metal screen (i.e. an abrasive steel huller), found only in Thailand. This mill is used for both dehusking and bran removal (at different settings and often using separate machines). Rice breakage can be a problem.

Three materials are produced by the sheller: husk, unhusked rice which is returned to a sheller, and the dehusked rice called brown rice, cargo rice or pinawa. A "paddy separator" is used to remove unhusked paddy and an aspirator to remove the lighter husk from the brown rice.

Whitening: Removal of bran layers, also called pearling, scouring, milling, debranning, and polishing (but see Polishing below). The machines are whiteners but are usually named according to the specific type (below). There are two general groups, those using emery stone surfaces, called abrasive, and those using metal only, called friction types. It is common for both types to be used in sequence in the same mill.

(a) Abrasive cones: Emery stones in the shape of cones or more commonly, steel cones covered with an emery layer, revolving within a perforated screen usually equipped with adjustable rubber bars called breaks, or weighted exit gates, to create back pressure. Both horizontal and vertical designs with either narrow or wide end or cone up, are in use.

(b) Horizontal abrasive roll: Similar to the cones but in the shape of a cylinder and used only horizontally. The Apollo type mentioned above is surrounded partly by screen and partly by a closed steel shell. The Satake type is completely surrounded by a screen.

(c) Steel huller: The huller is a friction type with a horizontal ribbed steel cylinder surrounded half by closed steel, half by perforated screen and with a single adjustable bar to provide back pressure. In addition to its use as a one-pass mill and as the sheller stage of a two-step mill, the huller is also effective as a separate whitener. Different settings are required for whitening compared to shelling, and an abrasive material such as rice hull is added to aid bran removal.

(d) Horizontal friction mill: These mills consist of a steel shaft similar to the steel huller revolving within a perforated screen which has special indentations to increase abrasion. Various styles exist for the screens and for the configuration of parts, some employing air circulation (e.g. jet-pearler) or even water spray for cooling. Back pressure is derived from a weighted exit gate.

Two materials are produced in whitening, bran and rice. Most of the bran passes through the perforated screens during whitening so that separation of the remaining bran is a minor problem.

Polishing: A special polishing operation is employed in some larger mills to remove a very small amount of rice surface in a manner such as to improve the product appearance; also called brushing or refining. The machine, called a brush or polisher, consists of an inner shaft rotating within an outer shell, one or both being equipped with strips of leather, rubber, canvas, or even bristles which brush against the rice. The outer shell may be perforated to allow the polish to pass out. Both vertical and horizontal polishers exist. This operation is commonly omitted in mills of developing countries. However, one machine deserves mention, a combination steel huller followed by a horizontal polisher, probably designed to be used as a whitener-polisher, is in common use but often as a one-pass mill with the leather brushes worn away. Even when this machine is used with separate sheller, the brushes are often missing so that it is exactly equivalent to the steel huller alone.

Two materials are produced at the polisher, the polished rice, also called white rice or milled rice, and a small amount of polish.

Grading: Separation of whole from broken rice and separation of the brokens according to size. In this report, the whole rice is called "head rice", the very largest brokens are called second heads, the smallest brokens, brewers rice, and the very small chips, the fines. The segregation employed depends on the custom in the particular market served by the mill. Single pass custom mills do not separate brokens. Some smaller mills separate only the very finest particles. The word "grade" refers to the percentage of brokens of a certain size mixed in with the whole rice. Grading in terms of sophisticated quality standards, other than percentage brokens, is almost nonexistent in most developing countries. There is a certain amount of negotiation at every level of production and handling, but quantity, that is, supply and demand, usually influences every price much more than quality does. Graders are often reels with indentations or perforations, but screens and discs are also used.

Other equipment: Besides cleaners and separators already mentioned, important auxiliary equipment for the multimill layout includes elevators, bins and special feeding equipment to assure an even feed to the milling machines.

The final product of the milling process is called milled or white rice, or less commonly, pearled rice or polished rice. The term undermilled rice is applied to rice with only about 4% bran removal. The usual custom is to remove up to 8% in developed countries, but the term "white rice" is also applied to any degree of milling. Thus, milled or white rice can be the semi-milled product of the one-pass mill, a highly polished rice from a sophisticated mill or anything in between.

Parboiling

Parboiling consists of soaking, steaming and drying the paddy, then milling. The term parboiled rice refers to both the unmilled and milled product. The product is not precooked in the sense that it still requires cooking at least as long as raw rice before consumption, although some parboiled rolled products are ready to eat. During parboiling, the starch is gelatinized and loses its crystaline structure so that parboiled rice behaves differently from the nongelatinized raw rice. Consequently, many of the characteristics

of white rice processing cannot be translated directly to the processing of parboiled rice. For example, the parboiled kernels will safely withstand much more drastic treatment during drying and milling.

The major reasons rice is parboiled today include higher milling yields, possible higher nutritional value (controversial), resistance to spoilage by insects and molds, and above all, custom, that is, familiarity and preference for the parboiled product in areas where parboiling has been common for centuries.

The following procedure, currently practiced by subsistence farm workers in southern India, gives an idea of the probable origins and original purpose of parboiling: When the worker is paid in high moisture (over 20%) paddy during rainy weather, she will soak the paddy in hot water for an hour in a round clay bowl, drain it, place the bowl directly on an open flame and swirl the rice around the bowl with a handful of broom straws until dry. The result is a dry (14%) abbreviated parboiled product, sterilized and hardened, and thus, protected from spoilage and insects. If the soaking time were longer, the product would be very similar to conventional parboiled paddy. In actual practice, the product is immediately hand milled, cooked, and consumed. Since the milling is done by hand (described under Milling above), the gelatinization of the inner rice kernel and the drying and partial opening of the husk during parboiling is necessary to make an easily workable material from an impossible one (the high moisture raw paddy).

There are a number of different parboiling procedures in India alone, where consumption of parboiled rice is most popular. In addition, there are special practices in other countries, and there are products different from but closely related to parboiled. Examples of some common methods are:

(a) <u>Parboiling in households for future use (southern India)</u>: One or two quintals of dry paddy is soaked in cold water in earthen/cement tubs for 4 to 8 hours. The partially soaked paddy is then transferred to another earthen or metal vessel and one or two liters of water added; the top of the vessel is covered with a wet gunny sack. The vessel is heated using leaves, twigs or coconut husk. The water starts boiling and steams the paddy. When the husk splits, the paddy is transferred onto mud/cement floors or on to a palmyrah mat spread over the floor and dried in the sun to a moisture level of 18%. Then this paddy is dried in the shade for 3 to 4 days and bagged. Whenever rice is required, some quantity of parboiled paddy is milled in a huller, winnowed and stored.

(b) <u>Parboiling on a custom basis (southern India)</u>: People who cannot undertake parboiling in their households are issuing paddy to custom parboiling and milling units for processing. In one such unit, facilities exist for soaking, steaming and drying 2 to 35 quintals of paddy at a time. The paddy is soaked in cold water in ground level cement tanks after initial steaming (presteaming) of raw paddy. After soaking for 24 to 36 hours, the soak water is drained and paddy is steamed in separate steaming vessels. The parboiled paddy is sun dried in the yard until the moisture drops to about 14%. After tempering overnight, the paddy is milled in the huller.

The milling unit (Engelberg type) consists of one No. 7 huller of 1/2 ton/hr. capacity with an attached winnower grader. Both units are operated by a motor of 15 HP. The paddy is passed twice or thrice through the huller depending upon the desire of the customer for getting rice with better appearance. Rs. 6.00 ($.75) per quintal of paddy for parboiling, drying and milling is charged from the customer. The bran is retained by the miller. Whenever customers take dried parboiled paddy, Rs. 3.75 ($.50) per quintal is charged. The rice and bran are taken by the customer. (P. Pillaiyar, private communication)

Because of the long soaking period required for thorough penetration of moisture when a cold soak (or mildly warm soak) is used, fermentation occurs imparting a sour flavor to the final product. Even when the paddy is cleaned and the soak water changed, growth of microorganisms usually persists. Some attempts to limit microbial growth by use of chemicals (e.g. sodium chromate) in the soak water have been made. The approach of procedure modificaton, in particular, reduction of the soaking time, has had a good acceptability, most popular modification being the CFTRI method.

(c) <u>CFTRI (Central Food Technological Research Institute, Mysore, India) method</u>: Clean soak water is heated to 85°C by steam from a separate boiler (or separate water heating tank is used). The addition of paddy (preferably cleaned) reduces the temperature to 70°C which is maintained throughout the 3 hour soak. The soaked paddy is drained and steamed until the husk splits open, then dried by sun or mechanical drier. The essential improvement is the heated soak which reduces the soak time and eliminates fermentation, although a specially designed tank with pipes for uniform steam injection improves that phase also. Two reasons for the widespread adoption of this method is its versatility and its suitability for small operations. In some places in India, the boiler is a 55 gallon drum set in brick heated by burning husk, and the tank consists of two such drums stacked and welded together with a special discharge welded to the bottom. At the other extreme, many large modern plants also use this procedure or a similar one.

(d) <u>Other modifications</u>: Another modification of the basic parboil procedure includes the use of high pressure steam. Since special apparatus is required for pressure parboiling, it has found only limited use in developing countries.

A procedure for one step soaking and gelatinization without the use of any boiler or steam has been developed at the Kharagpur Indian Institute of Technology in which the soak water is simply raised just above the gelatinization temperature of rice. Experimental work at other locations has focused on roasting, or using hot air to gelatinize. Some of these procedures yield products which are somewhat different than conventional parboiling. For example, a soaking, roasting and rolling (flaking) procedure has been used for many years to produce a precooked rice flake. The roasting and flaking accomplish drying, milling, par-

boiling, and flattening of the rice which allows it to be eaten as is or soak up liquid readily. This product is gaining rapid acceptance in some areas as a substitute for parboiled rice.

Other

Each country has unique problems and opportunities, as well as research efforts or other factors, which do not fit under the phase headings. Such factors are discussed in the Country sections after the sections on the phases of processing under appropriate headings.

ASIA

General Discussion

It is well known that Asia produces and consumes more rice than other areas of the world. What is not always appreciated is the diversity of conditions existing in Asia, including wide differ in climate, social and mechanical sophistication, customs and preferences and in every other possible factor affecting rice technology. For example, the very low losses of rice in Japan can be attributed as much to the cool climate as to Japanese care and sophistication. The tropical countries would never have such low losses (less than 5% overall) with the same care, because chemical and biological activity is so much greater under the warm tropical conditions. On the other hand, the warm climate allows multiple crops and the potential of greater production.

Differences in history and government have also influenced the diverse evolution of rice technology in Asia. The experience of Japan and Taiwan in developing successful rice systems based on very small farms has lessons for other countries wishing to follow the same path. For example, machines no longer in use today in Japan may be appropriate for other areas now at the level of development in rice that Japan was when these machines were used there. India, which has experienced some success in their development programs, is now sending technical personnel to assist other countries with their programs.

Thus, Asia exhibits similarities which can be transferred from region to region but also differences which require each region to be considered individually.

The statistical data appearing at the beginning of each country assessment are to give the reader a ready indication of the relative quantities involved. The data are from published USDA sources (6) or from working papers of the Foreign Agriculture Service or of the foreign governments. Some of these data are estimates only.

JAPAN

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	2622	2724	2764	2757	2458
Yield - MT/ha	5.79	5.64	5.95	5.94	6.40
Production - ThMT	15187	15365	16456	16368	15729
Milled P. - ThMT	11051	11186	11922		
Imports - ThMT	24	57	35	10	
Exports - ThMT	572	328	52	--	
Consumption (USDA) Kg/Cap	100	100	101		
Production (USDA) Kg/Cap	102	102	108		

Japan is not a developing country. As a rice producing country, it is most likely unsurpassed in utilizing sophisticated technology on a large scale, and certainly is unsurpassed on efficiency of small-scale rice operations. Japan might be considered to be at a stage of development in rice handling practices, including minimizing processing losses, that other developing countries would aspire to. The authors visited Japan before any other country to become familiar with farm-level technological developments, both successful and not so successful. In addition, the authors expected to gain philosophical insight into Japanese successes in developing countries.

In Japan, there are about 2.7 million hectares of farm land, 60% of which grows rice (3 million farms). There are three categories of farmers in Japan: (a) Principal (full time with own equipment), (b) Part time where farming is greater amount of income than outside job (shared equipment possibly), (c) Part time where outside income is greater than farming (shared equipment). In 1976, the percentage breakdown of the persons involved were: (a) 13.5%; (b) 20.5% and (c) 66.0%.

After threshing, drying and husking, the brown rice is sold to the government and graded into six different grades. Brown rice procured by the government is sold to about 400 licensed wholesalers at a subsidized price and then distributed for whitening and retailing.

About 9 MMT of milled white rice is consumed directly as food, 1 MMT is used in brewing, confectionary, and industrially. It was stated that farmers use mechanical equipment only 10-15 days per year. In Japan, postharvest rice losses are maintained at a very low level, not exceeding 5%, total. Part of the reason for the low loss must be the very high internal price of rice, maintained at over twice the world price.

Threshing

In Japan, the single rice crop a year that is possible with the prevailing climatic conditions is harvested mainly by machine, either self-propelled binders or combines. Approximately 60% of the crop is threshed by various kinds of powered threshers and 40% by head feed combines. The amount of manually threshed paddy is minimal. A power thresher of the type offered as an example, PK50, yields 430 Kg/hr at a quoted cost of $2,800. Twenty

to fifty years ago, Japan used manual cutting/binding, followed by locally manufactured pedal threshers. The designs of these pedal threshers are still offered for sale by export firms (e.g. CeCoCo).

Drying

In 1975, the rice crop was harvested at moisture levels between 20 and 30%. This crop was dried as follows: sun-dried (27%); farm mechanical dried (63%; 1.7 million driers), and cooperative mechanical dried (10%, 1100 driers).

Types of natural paddy drying in Japan:

1. Windrowing
   a. Flat bundles
   b. Conical vertical shocks
   c. Horizontal stubble supported panicles
2. Rack
   a. Single inverted stalk
   b. Multiple rack inverted stalk
   c. Multiple bar A frame
3. Sheaves
   a. Vertical orientation
   b. Horizontal layered
   c. On center pole

Types of artificial paddy dryers in Japan:

1. Ventilation dryer (no movement of grain during drying cycle)
   a. Box type (hand)
   b. Vertical plenum batch type (elevator)
   c. Horizontal tapered screen type (air)
2. Circulation dryer (circulated continuously or intermittently)
   a. Modified LSU type - thermal gradient
   b. Modified LSU type - pressure flow
   c. Modified LSU type - husk fired
   d. Cylindrical cone type
3. Continuous dryer (straight through designs)
   a. Baffle type vertical
   b. Screen type vertical
   c. Horizontal belt screen
   d. Inverted troughs
   e. Multiple air ducts type

4. Country Elevator - owned by cooperative
   Purchases rice from farmer - tempering dryer

5. Rice Center - owned by cooperative
   Tempering dryer

Abbreviated descriptions of these mechanical driers are as follows:

Box type driers

Rice is 40 cm deep
Drying rate is 0.7% moisture reduction per hour
Fire and breakage were problems

Recirculation type drier

Double tank type
Upper one is tempering
Lower is drying
Tempering time 1/2 hour
Multi-pass
Reduction is 1/2% moisture each pass
Continuous dry air temperature 40-50°C
Rice temperature is less than 40°C
Most are kerosene fired
Automatic moisture drier goes on and off
Start 25% usually - cycle 1 hour
Over 20% more than 1% reduction per hour
Under 20% less than 1% reduction per hour
Kaneko alone building 25,000 units per year

Parboiling

Parboiling is not practiced in Japan.

Milling

Almost all paddy in Japan is milled in a two stage, two time operation distinctly different than in any other rice producing country. Within a short time after harvest and drying, the paddy is dehusked and the resulting brown rice is stored under ideal conditions until a later time (just prior to consumption) when it is debranned (or whitened). There are two different systems used and a number of variations and degrees of sophistication on each, depending primarily whether the rice is the portion turned over to the food agency or the portion retained by the farmer for his family's consumption. Dehusking is accomplished by use of either individually owned small rubber roll huskers (1 million) or in cooperatives (rice center) with integrated operations. Debranning is accomplished by use of individually owned (one family or neighbor) whiteners on an as-consumed (daily) basis, or by The Food Agency (government). The government portion is milled by some 500 large rice mills with a capacity of between 3 to 30 tons of brown rice per hour and 20,000 small rice mills of a capacity of 0.5 ton of brown rice per hour.

The Japanese consumer is most insistent upon his rice being freshly milled. In his home he will mill usually one bag full (30 Kg) at a time.

Machinery is very expensive. Some examples are as follows:

Rubber roll huskers - on farm with diesel power:

Sinomier MB30	$825
Mitsubishi NM7-11D	$770
Yanmar NSA 40C	$530

The whiteners:

1/3 hp	Satake MC250, 14 Kg/hr.	$255
1 hp	Satake BSIF, 30 Kg/hr.	$380
	Aoki AP1, 50 Kg/hr.	$360
	Milltop (Satake)	$350
	Shellmaster (Satake)	$700

Commercial machinery available is very sophisticated and rugged for continuous duty and is used throughout the world.

Japanese Thoughts on Problems in Developing Countries

1. To replace the steel hullers now in general use in most developing countries, Satake would recommend a "Shellmaster" (paddy separator, sheller, whitener) of which the cost would be about $3000. This unit would also require a proper cleaning system ahead of it.

2. Rubber roll sheaths are a problem in import due to taxes, licenses, exchange, etc. This is somewhat aided when the sheaths are made in-country, but usually the quality is lessened. The best quality is Elephant Brand (Mitsubishi) from Japan. Good replacements are made in Taiwan. Sri Lanka has rubber but not the know-how. In the Philippines, a set in "Milltop" should husk 40 tons/set. Suzuki manufactures sheaths . in Brazil.

3. Companies in Taiwan collaborate with both Iseki and Yanmar.

4. Satake has experimented with a mixed technique, one abrasive and one rubber roll. The result is more brokens with about the same cost. Therefore, they have looked elsewhere for substitute technology. (Authors: this could be of advantage in a developing country that was not quality (% brokens) demanding, as the abrasive roll could be of local manufacture, and it is possible that local rubber technology might match better to effect a better economic balance).

5. Mr. Ishida (Satake) feels that the smallest machines, as used in Japanese homes, are not suitable for developing countries. It must be remembered that these machines are designed for light duty (30 days/year) and not the year-round commercial work as is practiced in village mills. The target

for developing country mills is for a quick, simple, lesser quality but a better recovery. He would expect a different type of mill and would not see a long term market available.

6. There must be an incentive for improved quality factors necessary to encourage development and manufacture of sophisticated (costly to buy and to run) equipment.

7. The Japanese do build and offer (Cecoco-Kagawa) low technology manufactures suitable for some use. Some of this is patterned after or is equipment as used in Japan in earlier years. These machines are manually operated, cheaply made, simply constructed, and rugged.

KOREA

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	1182	1204	1218	1219	1230
Yield -MT/ha	4.95	5.13	5.32	5.94	6.21
Production - ThMT	5850	6174	6485	7243	7639
Milled Prod. -ThMT	4212	4445	4669		
Imports - ThMT	247	467	200		

Korea has a population of circa 35 million. The average rice farm size is 0.95 hectare with only one rice crop possible per year. Both indica and japonica varieties are grown. A large farmer can be expected to produce about 10 MT/yr, a small farmer, 2 MT. Lately, there has been a preference to grow Tongil, an indica variety which, though high-yielding, shatters easily with concomitant losses.

The Korean Institute of Science and Technology (KIST), a government organization and Seoul University estimated rice postharvest losses as follows:

Threshing	1%
Farm storage	7%
Commercial storage	3%
Milling	1.5%
Distribution	2.9%

A draft of a report on milling losses observed during the use of five different rice milling systems had been prepared for IDRC but has not been made available to the authors.

Threshing

Threshing techniques in Korea include hand beating, the hand comb separator, foot-pedal drum thresher, and powered drum thresher and the semi-automatic self-feed thresher. The pedal thresher was popular in Korea in earlier years but now mostly the power thresher is used both with automatic feed and semi-automatic feed.

Drying

Most drying is done by sundrying. The rice stalks are cut by hand near the ground and laid out on the stubble in small bunches. After a couple of days, the bunches are tied by hand with a few rice straws. After a further 2-4 days in shocks, the rice is ready for threshing. Typical moisture levels quoted were: 23% harvest, 18% into shocks, 15% into thresher.

No mechanical drying has been reported in Korea. However, Baek of the Ministry of Agriculture and Fisheries, Crop Improvement Center, has developed an experimental rice hull furnace to use as the heat source for a batch type drier similar to the IRRI design dryer in 1976. A paper on development of this furnace and drier combination is due to be published.

Parboiling

Dr. Chung of KIST believes there was no parboiling, whereas Dr. Lippold of the Crop Improvement Center believed there was a small amount of parboiling in the South. The authors were unable to clarify these opinions.

Milling

Milling rice in Korea is usually done in a local custom mill using Korean made machinery. Up to 10 years ago the machinery was imported, but today all types are manufactured in the country. The government has about 150 milling stations in the country. In a village where there are 3 or 4 mills, the government will appoint one, and the others will mill privately. Husking is with rubber roll huskers--whitening is by cone whiteners, or with a jet (friction) pearler. Most mills are changing to jet pearlers which the government recommends for both indica and japonica varieties. Rubber roll sheaths are manufactured in Korea.

Paddy identity is maintained by the farmer and the milling is maintained by separate variety. The average mill is 120 Kg/hr/hp with 17-25 hp. As an example, the Sam Gwang Cheong Mill (KM) had a paddy cleaner, 2 rubber roll shellers, one large, one small. A stoner existed ahead of the whitener; a large abrasive whitener with six other whiteners, both jet pearlers and horizontal abrasive cones. This was a lineshaft mill with a large electric motor for power.

Projects in Korea

1. IRRI Cooperative Project on postharvest skills.

2. KIST: Investigation of milling plants in Korea.

    a. Survey on private custom mills--80% of the domestic production.
    b. Review of all plants in small scale.
    c. Actual measured milling rate in private and commercial plants.
    d. Measure all losses and assess the sources.
    e. Key to all milling outturn.

3. KIST: Rice postharvest technology under an IDRC grant, to determine most critical areas of losses.

4. Proposing second phase for IDRC project: More detail on modified systems in terms of new threshers, dryers, storage units, including actual field testing.

5. TPI: Grain losses investigation.

6. Seoul National University: Direct comparison of sun drying and mechanical drying and development of viable drying systems.

TAIWAN

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	742	778	790	778	770
Yield - MT/ha	4.12	4.27	4.32	4.62	4.45
Production - ThMT	3,057	3,324	3,415	3,592	3,426
Milled - ThMT	2,097	2,280	2,343		
Imports - ThMT	-	127	30		
Consumption Kg/Cap	137	139	139		
Production Kg/Cap	132	140	148		

Over the past 20 years Taiwan has progressed from a hand and animal labor based rice producer to a highly mechanized one even though the average holding is only 1 hectare. In doing so, Taiwan has faced and overcome many of the major problems now facing developing countries especially in the realm of rice machinery. Taiwan has imported, tested, modified, copied, invented, produced under license and even exported rice equipment of every sort, all of the small size and reasonable economy which would be useful to developing rice systems in other countries, especially those based on small land holdings. There have been failures, bankruptcies, changes in policy, perhaps some errors in judgement and problems not yet solved or new ones arriving. However, the overall bottom line is success, especially in the major problem areas seen repeatedly in country after country on this assessment tour.

Thus, Taiwan is useful not only as a source of machinery and information on its use but also as a source of experience, good and bad, in dealing with the institutional, social, and other non-mechanical problems associated with the developing rice system. The machines now exported by Taiwan were made primarily for use on Taiwan and many have been adaptions of imported designs (mostly Japanese and U.S.) without major change. But the testing of the machines, the acceptance, use, and eventual domestic manufacture shows the suitability of these particular ones to a small-scale system which is not highly subsidized (as is the rice economy of Japan). Also the particular design changes chosen must have been directly related to the needs of the local system. Machines include pumps, power tillers, tractors, transplanters, weeders and other aids to growing rice, and threshing, drying, and milling units for post harvest. The pumps, power tillers, and threshers, have contributed greatly to the rapid progress.

Manufacturing costs in Taiwan were originally greater than the imported item cost, and the workmanship was poor. Now the cost of many items is quite competitive and the durability of some items is reported to surpass that of the imported model which was copied. A good analysis of the progress in rice mechanization as well as some of the problems, can be found in an article in English by Tien-song Peng of the Joint Commission on Rural Reconstruction (JCRR), printed in the back of the Taiwan Agricultural Machinery Guide (17). The JCRR is a semi-government agency which has promoted the agricultural mechanization on Taiwan. Much of the following description is taken directly from that paper.

Threshing

In Taiwan, the paddy is still harvested with a small, light-weight hand-sickle. A pedal thresher with a threshing cylinder mounted on skids is pulled around the field to follow the reapers. One man can cut about one-half acre of paddy per day with a sickle, and two men with a pedal thresher can thresh two or three tons of paddy in a day. After threshing, the grain is carried to a courtyard for drying, winnowing and cleaning on a concrete ground.

A thresher driven by a small 3-5 hp gasoline engine instead of a pedal has been developed and widely adopted by local farmers in recent years. At present, there are about 128,000 rice threshers still being used in rural Taiwan. The figure is less than that of a few years ago, serving to show that more farmers have adopted the highly efficient power-driven threshers. Improved power threshers equipped with cleaning devices have been developed and extended to local rice farmers, also.

In 1967, two kinds of hand reapers, pushing and pulling, modified from Japanese-designed ones were manufactured locally for extension. However, they have not been extensively used due to higher grain loss and other drawbacks. Thus, their production of reapers was soon abandoned, both hand pushing and pulling reapers are no longer in use. About 1,000 power driven reapers or cutters have been introduced from Japan for trial use.

In 1970, a number of small Japanese-made rice combines consisting of a reaper and an ordinary automatic power thresher were introduced by the local manufacturers for testing purposes. So far some 2,000 small combines have been extended to rice farmers and there are three local manufacturers ready for production of such machines. However, there are still some shortcomings of the machine such as:

a. The grain shatters very easily especially for Indica rice as the cutting and gathering devices of the machine are not gentle enough to keep the grain intact.

b. The gathering mechanism of the machine fails to gather up all the lodging stalks.

c. Some rice-fields are too soft at the harvesting time to support the heavy machine.

d. The small, uneven rice-fields of Taiwan make the use of the combine less efficient as its working capacity is only 0.6 to 1 hectare a day.

e. The machine does not operate well, particularly with respect to its cleaning device when the moisture content of the grain is too high during such operating times as early mornings or after rainfall.

One manufacturer (Young Eagle) quoted a price of about $250 (FOB Taiwan) for his thresher including reciprocal separator, aspirator (chaff blower), two screens, one for wet and one for dry threshing, but without the required 5.5

hp motor. These threshers come in two sizes, weigh less than 150 kg and are provided with skids for ease of movement over wet ground. These threshers were seen everywhere during this assessment tour.

Winnowers cost $55 (hand or without motor), or $75 with 1/4 hp motor. These are such simple machines that they can probably be easily built by anyone near the location of use. (See Drying below).

Because of the two crop system used in Taiwan, the rice is threshed in the field then removed to dry. The straw is piled to dry at the side of the field or burned on the field surface.

Drying

The normal drying procedure is careful sun drying on cement or asphalt yards near the fields. The rice is put in rows of piles and turned carefully periodically while drying over one to three days. About 80% is still dried in this manner although wet season losses have inspired the increased use of artificial drying. The experience is described by Peng. It goes without saying that adequate rain-water hastens the growth of various crops, particularly rice. But when the long-drawn rainy days coincide with the harvest season, the full-grown rice in the field or the newly-harvested grains spread on the drying ground may sprout and sustain various degrees of damage.

The annual loss throughout the whole island is high, because the harvesting time of the first rice crop in southern Taiwan and that of the second rice crop in the north usually fall in the rainy season. When the rain comes in the midst of harvesting, the farmers have no choice but to pile their grain on the drying ground and cover it with straw and pray for the end of the foul weather. If the rain lasts for several consecutive days, the wet grain pile will gradually get warm as a result of heat accumulated through transpiration. The temperature in the center of the pile will thus go up, resulting in fermenting, sprouting or molding. Heavy damage to rice has been repeatedly reported in the past decade.

In order to save a sizable amount of rice from spoilage by rain or high humidity, several types of rice driers were purchased from the United States by JCRR for testing purposes 20 years ago. These were: a portable rice drier made by the Behlen Manufacturing Co.; a column type rice drier by the American Drying Systems, Inc.; and a small portable rice drier by the American Drying Equipment Company. Preliminary tests revealed that the Behlen portable drier entailed the lowest drying cost, while the other two produced rice of better quality. However, all the driers were either too bulky or too expensive for the individual farmer to own. A lighter drying bin with a motor blower and a burner for artificial drying of rice was developed for extension by the Provincial Department of Agriculture & Forestry (PDAF) experiment stations, in cooperation with the China Agricultural Machinery Co., Ltd. in 1966.

The bin-type artificial grain drier is portable, weighing about 270 kg. In the ordinary harvesting time, the grain drier could reduce the moisture content of the grain from 23 to 13 per cent and turn out about 1,500 kg of dry rice every 21 hours. In the rainy season, the drier could even be operated 24 hours a day. The fuel for the burner of the drier is kerosene, while its

1/2-hp motor blower uses electricity as source of power. Up to the present about 7,700 units of the drier have been extended to local farmers for adoption. Meanwhile, some 1,600 units of circulation-type driers of local manufacture were also adopted by farmers. So far, about a dozen local farm machine shops are producing these driers for local use.

In the meantime, several farmers' associations and some agencies concerned have constructed bigger driers for commercial purposes.

The circulation type driers mentioned above are the type which have the advantage of tempering between actual drying treatments without having the rice leave the machine. The tempering while drying reduces the breakage during milling. However, the cost of circulating driers is much more than the bin type. They are made in Taiwan in cooperation with Japanese companies and are of the same design as found in Japan.

Paddy grains after drying have to go through a winnower once or twice before being sent to the market. The winnower is generally made of wood, but some factories are producing winnowers made of sheet metal. A revolving fan inside of it is cranked by hand to produce an air blast for removing the chaff, straw, dust and unripe grains. Plain bearings were usually used in the revolving mechanism. Only in recent years ball bearings have been adopted by the manufacturers. On an average, 180 hectoliters (511 bu or 230 cwt) of paddy can be cleaned by a winnower on a one-run basis.

Since electricity is available in most of the rural areas, some winnower factories have developed an electric motor-driven winnower to replace the hand-cranked one. Some of them are even equipped with an auger elevator to transport the grain into the hopper of a winnower at higher speed with less labor.

Meanwhile, due to wider adoption of power threshers without cleaning units, a kind of grain and straw separation device has been developed locally and extensively used for cleaning the newly threshed grains. The separator equipped with a sieve and a blower driven by a 1/4-hp electric motor is a labor saving device.

Parboiling

There is no parboiling in Taiwan.

Milling

Rice hulling and polishing equipment is mostly operated by local farmers' associations and some businessmen to serve all the farmers in the respective areas. Most of the machines are equipped with an oil engine of 7 to 12 hp or 7.5-hp electric motor, and have a capacity of hulling and milling 2 to 4 metric tons of brown rice per hour. Recently, a number of smaller rice hullers and polishers have been adopted for individual and/or cooperative use by the farmers.

Taiwan is in the process of upgrading the older milling operations, in particular the cooperative mills. Thus it is possible to see the old mills, with

some unusual machines such as a friction mill with no screen, the bran separation being done later and new mills with the latest designs (very similar to the Japanese) including local innovations of various sorts.

It was reported that brokens were eaten domestically thus reducing "losses" from breakage to the increase in powder and small chips. The specifications for export are 15% broken for Japonica and 25% for Indica rices. There is a grader used after milling which removes about 0.5% very small brokens.

The manufacture of milling equipment is one area where Taiwan entrepreneurs have successfully entered the world competitive markets. Most of the mills exported are commercial types and usually go to Central and South American customers.

Another type of mill just coming into use in Taiwan is the Japanese style family mill. It appears these may be made under cooperative agreement with some Japanese manufacturers since the designs seem identical. Although it was reported in Japan that these machines are designed for intermittent home use and not rugged enough for continuous commercial operation, especially under the adverse conditions found in many developing economies, they are almost the correct size and capacity to replace the one-stage mills now widely used at the village level. It would be interesting to see if innovators could build a suitable machine from this base. They are now somewhat expensive compared to the price in some countries for the Engelberg style mill. These innovations may not occur in Taiwan, however, since the holdings in Taiwan are so similar to those in Japan that the family mill will probably be useful without change.

Other

The experience of Taiwan in mechanizing their farm operations and upgrading their mills rather successfully in a short time must have lessons for others wishing to do the same. The difficulty in establishing viable cooperatives was evident, with the need for a strong extension organization being a part of the success formula. The JCRR promotion is another important factor. The testing of equipment, which we did not observe, seems a necessary prelude to promotion and such programs do not exist in many developing countries. Original research is not a characteristic of the research facilities visited, but the ability to copy successfully the designs of others and put them to use is remarkable.

Taiwan seems to be following the history of Japan. They are at a level between Japan and the developing countries sharing the characteristics of each. They are unique in that the equipment and programs are the proper scale to be applied to village operations, yet are completely commercial in nature. The fact that Taiwan has continuing problems in its development emphasizes the fact that development is not something which can be accomplished instantaneously but rather something that requires continuous effort.

PHILIPPINES

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	3435	3539	3681	3509	3620
Yield - MT/Ha	1.63	1.60	1.77	1.96	1.90
Production - ThMT	5585	5651	6515	6895	6885
Imports - ThMT	318	209	70		
Per Capita Cons. - Kg/yr	84	83	82		
Per Capita Prod. - Kg/yr	86	85	83		

Quantitatively, the rice industry in the Philippines is in the hands of the farmer and the private sector. National Grains Authority (NGA) handles less than 10% of the total, though it is the chosen instrument for control of all imports and exports. The cooperative sector handles a bit less than 10%, the private trader about 50%.

The average paddy farm size is about 1.7 hectares. The marketing system is not prepared for the bounties of multiple cropping. The farmer is able to accept new varieties, fertilization, and the idea of mechanical threshing but resists the concept of mechanical drying or advanced storage practices.

The Filipino eats only white milled rice, and if you should look in the market, you would find usually a 50% broken product. There is no premium for quality in the market place; therefore, there is no incentive to the producer or the miller, and with the controlled floor price on paddy and ceiling price on milled rice, there is no possibility of a spread to accomodate quality considerations. Therefore production suffers, and the lack of incentive stifles the advent of drying and storage in the mass market and production areas. Only in the government showplaces does an effort at improvement respond.

There is some hope in the cooperative sector, if the momentum developed can be continued. The viability and improvement at the level of the SN (Samahang Nayon), a cooperative of 50-60 farmers, and the coordination of these SNs into the AMC (Agricultural Marketing Cooperative) (200-300 SNs) should prove out. The cooperative movement provides training and extension and credit to the individual farmer. The AMCs already have drying and storage capacity as well as marketing capability, but true progress in overall production can only come when drying is accepted at the lower SN level. The main resistance to increased planting in the rainy season is partly due to the rainy season transport problems and partly due to the built-in resistance to planting something that currently stands a 60/40 chance of being lost when harvested.

There is no working grading system in the Philippines. Most of the so-called grading premiums are really based on moisture content. NGA pays 1P/Kg for wet paddy and 1.15P/Kg for clean dry paddy. The trader pays down to 0.75P/Kg for wet paddy which is more realistic compared with the clean dry price. It appears that there is a market (urban) for a better grade of milled rice, a so-called "fancy" variety. Because consumers will pay higher prices for better lots of rice as they are offered, most purchases are on an "as negotiated" basis for each lot.

Estimates of grain losses in the Philippines that occur during postproduction operations from harvesting, threshing, drying, milling, storage handling and marketing were as high as 37% of total production. Handling losses are greatly influenced by moisture levels and maturity at time of harvest. Every additional handling step seems to embody a loss of 1 to 2 percent for varieties with high shattering characteristics. The NGA has estimated losses at:

Harvesting	3.5%
Threshing	2%
Cleaning	2-4%
Storing	6.5%
Milling	5%

IRRI estimates losses at:

Harvesting	1-3%
Handling	2-7%
Threshing	2-6%
Drying	1-5%
Storing	2-6%
Milling	2-10%

Government actions completed, in progress, or planned to reduce postharvest losses include: (1) Four-year Development Plan which has, as one of its major objectives, the attainment of self-sufficiency in food products, and, (2) Masagana 99 Rice Production Program.

The Philippines has high levels of expertise and support for rice research. These groups, IRRI, SEARCA, and UPLB, acknowledge rice postharvest losses, and are committed to reducing these losses through research, development, and extension work.

Threshing

There are five traditional and eight mechanical systems used in threshing paddy grain from the manually cut stalk. The traditional systems are:

1. Beating-Impact (hampasan), a manual method in which the bundles are impacted against a solid object, tub, screen or bamboo frame; yield is about 500 Kg/man/day with stated losses of 6-9%.

2. Flail, using a stick or hinged device to beat small stacks or bundles to separate the grain from the panicle; yield is about 500 Kg/man/day.

3. Animal treading; yield is about 1500 Kg/animal/day.

4. Manual treading; yield is about 150-200 Kg/man/day.

5. Stripping by pulling straw and panicle through a V cut on a piece of wood or a comb.

The mechanical systems are:

1. Pedal thresher (manually powered), usually with loop teeth. Five man crew - 600 Kg/day.

2. McCormick-Deering Thresher, throw in type; crew 8-10 men; two sizes:
   50 hp tractor - capacity 2000 Kg/hr.
   75 hp tractor - capacity 3000 Kg/hr.
   Needs dry paddy, less than 21% moisture, is large, heavy, needs dry fields.

3. Double Drum peg tooth, wet paddy satisfactory. 1 0 hp - 500 Kg/hr; trade name "Magico".

4. Single Drum, throw in; with cleaner; portable. 5 hp - capacity 400 Kg/hr; four man crew Named "Guaranteed". For wet or dry paddy.

5. IRRI axial flow; 500 Kg/hr; 3 man crew; 9 hp engine. Wet or dry paddy. The machine can be broken into 3 components for field transport.

6. Cotabato Thresher, double drum Kyowa type peg tooth; throw in; wet or dry paddy. 500 Kg/hr; 5 man crew.

7. Elfa Thresher; throw in; 750 Kg/hr; 5 hp; no cleaner; 5 man crew.

8. IRRI Portable, not as good on wet paddy; no access for cleaning; 200 Kg/hr.

The traditional methods are more widely used (80%) than mechanical methods (20%), but both the older McCormick type threshers and the two new IRRI models have increasing popularity. The larger IRRI designs are capable of working on paddy which is quite wet. The axial flow thresher has a cleaner integral and the small one is now being designed with a cleaner. The other designs noted are increasing in popularity in their respective regions.

Farmers are accepting the ideas of mechanical threshing to help ease the labor shortages caused by the introduction of high-yielding varieties and the shortening of the time between crops. It is normally suggested that the crop be brought in within 24 hours. Presently, it takes about three days because of the lack of adequate threshing machinery. Threshers that work efficiently for the dry season crop may choke with the wet straw and freshly cut stalks. The stated cost of an IRRI Axial Flow Thresher is 14000 Pesos ($1860) including engine. If a 5% threshing charge were levied upon 180 cavans of 50 Kg each per day, it would take 57 days' operation to recover the investment. It can, therefore, easily be seen how, in the irrigated areas, threshers will proliferate.

Grain Cleaning

The prevalent grain cleaning method in the Philippines is manual winnowing. In this method, the removal of dockage such as straw, chaff, weed seeds and other foreign materials is accomplished by utlilizing natural wind or manually operated blowers. If a mechanical thresher with an aspirator is available, no

additional field cleaning is done. Where the field grain is sold to processing plants where paddy precleaning facilities are available, the entire lot, straw, chaff, and stones are brought to the plant. The processing plant usually attempts to measure dockage and deducts this from the gross weight of the grain delivered. The procedure and facility for doing this has not been established and is an irritant between producer and processor.

Mechanical cleaning is not popular due to its high cost. There are two types of portable cleaners. One type, a rotary cleaner, has a high capacity and cost. The other, designed to reduce cost and size of the rotary cleaner, uses oscillating screens. The latter can be built at a cost of about $400 but has a lower capacity than the rotary cleaner and is rated at up to one ton paddy per hour, uses 1 to 2 men to feed and bag the grain, can be carried by two men, and is powered by either a 0.5 hp electric motor or a 1 hp gasoline engine. The rotary cleaner processes 2.5 MT/hr, requires a 3 hp engine or 3/4 hp electric motor and is believed better than the screen cleaner for cleaning very dirty or high-moisture paddy. Its cost, and manpower requirements to move and operate, were not determined.

Drying

The most common grain drying method practiced in the Philippines is sun drying. Planting is usually timed so that the paddy will mature after the rainy season to permit sun drying. Filipinos are accustomed to sun drying and possess ample skills in using it to the best advantage. Grains are spread on a flat dry surface, either on cement pavements or on bamboo mats, and occasionally stirred or raked so that the grain will dry uniformly. Some paddy is dried in shocks in the field.

The paddy is still high in moisture content after threshing so must be dried immediately. One of the harvest seasons occurs during the rainy months of October and November, and the traditional sun-drying practice is not feasible. The use of mechanical heated-air convection type driers seems to be the alternative. They are usually large, expensive, sophisticated in controls, require a high level of expertise to operate, and are intended for centralized drying plant operations. The small and fragmented farms, the introduction of new high-yielding, early maturing and nonseasonal varieties, and the lack of feeder roads and transportation to bring the harvested grain quickly to the drying plant work against the effective operation of centralized plant driers.

In order to alleviate the critical drying situation, there has been developed a program to promote the use of on-farm rice driers to save the grain. The introduction of a very low-cost batch type farm drier that farmers can build from locally available materials has been encouraged by various groups. Their use requires the minimum of complexities and does not damage the milling quality or viability of the grain. The program also moves the drying focus from the central storage or milling plants to the individual farms. This is to solve the time delay between harvest and drying. These farm units are not intended to eliminate central drying but merely to complement them. At the peak of the wet season harvest when the grain is very wet, 24-26% moisture content, the farm driers can extract the first 6-8% to slow the biological deterioration of the grain. At 18%, the grain then can take several days to reach the central drier where a final pass reducing moisture to the desired

storage and milling level of 13-14% may be done. This concept has been tried with farmer cooperators and central driers and appears to be a workable solution.

Farm Driers. IRRI has developed two types of batch driers (1) the flat-bed drier, and (2) the vertical bin batch drier. The flat-bed drier dries 1 MT of paddy in 4-6 hours with a drying air temperature of 110°F, and bed depth of 33 or 46 cm in one continuous operation. The drying bin occupies floor space of 254 x 254 cm. (6.5 sq. meters) for wood and 277 x 190 cm. (5.3 sq. meters) for metal and can be operated with either gasoline, kerosene, or rice husk to heat the drying air. Total cost is reputed to be about $300-$400.

The vertical bin batch drier dries 2 MT of paddy per load in 4-6 hours with drying air at 110°F in continuous operation. Grain bed thickness is 46 cm. The drying bin occupies a floor space of about 6 sq. meters and can be operated with either gasoline, kerosene, or rice hulls. The bin is made of wood and consists of 3 adjacent compartments with the center serving as a plenum and the side compartments as grain bins. The grain bins have removable horizontal sliding louvers inclined 60° toward the inside and outside to contain the grain and allow passage of drying air. A screen of hardware cloth is installed on the inside (plenum chamber) to prevent spillage during loading and operation. The outside louvers are removable for easy loading and and unloading. A wall partition is installed in each compartment to provide a means of drying 4 different lots at the same time. Unloading is accomplished by the use of a portable chute with bagging hooks which is inserted into one of the louvers. The bins can be used when partially full. Sliding panels are inserted on railings on the inside louvers of the grain compartment. The panels can be lowered to provide for shrinkage. Farmers do not like to have their grain mixed with that of other farmers, so the 4 compartments permit 4 farmers to dry simultaneously. Cost estimates are reported to show that the burner/blower assembly for the vertical bin drier is about 25% less than the flat-bed design, and that the complete system will cost about 45% less than the flat-bed design (on a per ton of capacity basis), and will occupy about the same floor space. A third type of drier is the Alvan Blanch sloping or cascade drier which has been used for many years in the U. K. Here, the paddy flows from the top down an inclined bed at approximately 30° past a series of agitators to the bottom. Air passes through the paddy from underneath and the speed of the paddy down the bin can be controlled to vary the drying rate.

Of the small sized driers now being developed, the IRRI louvered four compartments drier seems to be the most adaptable one to the very small farmer. With the louver design, there is no need for imported components, it can be fabricated locally with indigenous materials. The problem of small lots and farmer identity is taken care of. The farmer should be encouraged to construct a step grate furnace burning straw (which is plentiful) or other indigenous fuel (twigs, cuttings, etc.) to provide heat for an IRRI type louvered drier. He should be able to reduce the moisture of his paddy to 18% which would then allow a 10-14 day period for collection and transfer to the commercial or government driers.

When paddy is selling for 55 pesos dry and 36-38 pesos wet, the farmer will prefer to sell wet. Resistance to drying occurs because the farmer has lived with this problem, he cannot believe that it must not be so. He does not

attach enough value to quality paddy to make an effort to track down the sources of deterioration and do something about the conditions. He looks upon the paddy only as food for existence. He does not think as a commercial grower competing in a quality market. What is doubly serious is the effect this has on his decision as to what, how much, or when to plant his next crop.

Parboiling

At the present time, there is no parboiling in the Philippines. There is also no serious effort to establish any though FAO and SEARCA are encouraging studies and initiating parboiling projects. NGA is looking at parboiling to produce an export item, as a price stabilizing influence, and for buffer stocks.

Parboiling offers several advantages to the Filipino: (1) a dramatic increase in head rice percentage; (2) it could be used to save wet grain; (3) parboiled rice is a popular export commodity. The disadvantages are: (1) parboiling does not help in moving paddy from field in rain which is the key problem; (2) dislike of color, texture and flavor by the domestic consumer.

Milling

Rice mills are mainly located in the producing areas. The specific location is influenced by the infrastructure. Single stage units (Engelberg or Kiskisan steel huller) mills are located most often in widespread areas where the accumulation is in small lots and for milling for home consumption. The classic style (cono) mills are located in areas with larger collection centers for paddy. Geography and difficulties of transport, together with the size of farms and of the islands, appear to have determined the regional distribution. There is considerable variation in the distribution of different types of mills between regions.

A small amount (3-5%) of rice is processed by manual means. Two systems are noted: (1) the traditional mortar and pestle; (2) a technique wherein the dried plants are hand pounded in bundles (pongos) without passing through threshers. The largest portion of the Philippine rice crop (40-55%) is milled in steel huller mills with capacities ranging around 500 Kg/hr. The milling recovery is low (59% or less), and the value of the by-products is variable. However, these mills require only a small capital outlay and are very simple, have very low maintenance costs, and are accessible in barrios, which justify their popularity in the rural areas.

The more efficient under-runner disc sheller coupled with whitening cones is commonly known as a "cono" mill and is popular for commercial milling because of its capacity. Close to 3000 cono-type rice mills are in operation in the Philippines. Generally, most of these mills are manufactured locally. The capacity of these installations ranges from 0.5 MT-4MT/hr, but its performance is an improvement over the steel huller type. Cono mills have a milling recovery of 65% or more. They are generally thought of as a central unit, and they may or may not be associated with a dryer or large capacity warehouse.

A few integrated complexes have been built in recent years using a "modern" configuration. Both European and Japanese technology has been used with disc

sheller-rubber roll return sheller as one style and straight rubber roll sheller as another style. Whitening is accomplised with Japanese style horizontal abrasive rolls, and with friction pearlers, and with vertical one whiteners in one mill. These large mills have had many difficulties, primarily in the area of having to operate of capacity which causes severe economic problems. This has been mainly due to the lack of paddy.

There has been criticism of the Japanese designed whitening (jet-pearler) mills milling Indica type paddy. It is generally pointed out that the Japanese mill failed to become popular because it was designed to mill Japonica varieties and does not mill the Indica properly. This is not true; the Japanese mill will mill Indica types as well as any other. As an illustration, all of the new mills in the United States and almost all of the older mills (in the South) milling long grain types (some very fragile) use just this type of equipment.

The newest mill in the Philippines is a Satake "Compact mill". This 1 MT/hr mill with rubber roll sheller and a single horizontal whitener was introduced to farmer cooperatives in an attempt to improve the level of village milling. The tests were considered to be negative because: (1) the milling performance was not better than an Engelberg; (2) the need for constant rubber roll sheath replacement was costly and difficult; (3) the investment was much greater.

In order to force a supposedly better level of milling efficiency, various restrictions have been placed on new installations and improvements in recent years by the government. The much maligned Kiskisan (Engelberg) is blamed for almost all the country's troubles, but when its performance is looked at on balance, it is easy to see why it is almost impossible to stop their use. One rule was that any new mill must have a rubber roll sheller. Ones financed by World Bank funds and Asian Development Bank funds were mandated to install the rubber roll sheller. In many cases, this was done to get the loan, but as soon as the inspections were over, the operation reverted to a classical cono or Engelberg style. One exception to this rubber roll installation rule was in the case of a miller replacing a steel huller with a "Baby Cono". The rationale is that this is an improvement in overall efficiency. It was seen that in custom milling where a rubber roll was used, an additional charge ($.50/CV) was made for the increased operating cost.

There has been considerable interest in "flash" or centrifugal shellers being used. However, all centrifugal huskers seen were institutionally installed for test or demonstration purposes. NGA had installed three but stated that they were disappointed in their performance.

The following directive was taken from a bulletin board at an NGA Rice Service Center. "As a step toward a more efficient allocation of rice mill facilities all prospective grains businessmen intending to engage in the milling activity whether they are self-financed or will secure financing from any financial institution are hereby required to secure a written authorization from the nearest regional/provincial offices of the NGA before they can put up a new rice mill in any particular locality. Before a permit can be granted, feasibility studies on the viability of rice mill operations in said locality should be submitted by the prospective miller to NGA for proper evaluation. Furthermore, the milling recovery of new mills allowed to be put up should not

be lower than 62% by weight as provided for under Law 695. No new applications for license to operate rice mills shall be accepted by NGA, if the same are to be installed in areas found to have excess in milling capacity, if said mills failed to reach the 62% minimum milling requirement".

There is some use in the Philippines for portable tractor-powered rice mills which go to the farm to mill the farmer's rice.

Some of the rice mills visited by the authors were in deplorable condition. One NGA mill, only three years old, is not being used because of the dust problem. Several mills visited, particularly Marinas and Masagna showed excellent houskeeping and sanitation.

Recently, there have been considerable efforts put forth by financial interests, particularly the Philippine Development Bank which is administering grants ($14.3 million) from the World Bank, to encourage installation of new and efficient rice mills. The focus has been on moderate sized mills (250-350 CV/12 hrs) costing between 150,000-200,000 pesos. This figure is without driers or prime mover. Ideally, the configuration should include locally manufactured rubber roll husker and cone whitener, not much emphasis on grading but with adequate precleaning. The authors believe the Filipinos cannot make any money because of the fixed (by the government) spread and cannot get any more money (premimum) for better rice.

This lack of incentive, above all other factors, discourages improvement in the country's mills. It would seem that the only beneficiaries will be either NGA, local government or the cooperative sector.

In research efforts to upgrade farm-level operations and to decrease losses during rice milling, IRRI has carried out work to modify the traditional Engelberg mill to increase grain recovery. Modifications consist of:

1. A continuous single threaded screw at the feeding section of the rotating fluted roll.

2. A sectional cylinder to separate the process of feeding from milling and discharge.

3. Provision for an air jet stream passing through the rotating cylinder roll to cool the grain.

4. A weight loaded gate to control axial grain movement.

5. Two semicircular screens with adjustable supports to increase bran separation and to permit variations in the clearance with the rotating cylinder roll.

6. An adjustable blade relocated to the top of the machine to make full use of the two semicircular screens in bran separation.

7. A sectionalized rice mill casing for easy assembly and disassembly for inspection, measurement, and repairs.

Additionally, they have developed a system for two different-sized Engelbergs operated in series. Paddy enters the first mill (size #1), producing a mixture of brown rice, white rice, husks, ground husks, coarse bran, and brewers rice. Some fine materials pass through the internal screen in the huller while the main products are discharged into the second mill (size #7). Final hulling and whitening take place in the second steel huller mill. The products move to an oscillating double layer rice sifter where separation of rice and by-products take place. A rice aspirator cleans the rice before bagging.

Comparisons of Different Systems and Equipment

IRRI and the University of the Philipines at Los Banos (UPLB) have cooperated in performing a series of rice post production trials in the Bicol region of the Philipines in operations including rice harvesting, threshing, drying, and milling technologies. A summary of the empirical data is reported in their publication "The Technical and Economic Characteristics of Rice Production Systems in the Bicol River Basin", April 1978, Revised November 1978. The report includes a systems' approach in which a variety of operating equipment is combined and compared under commercial conditions. It gives equipment and operating costs for a wide range of postharvest equipment, surveys, grain losses, outlines postharvest practices, and assesses farmer, producer, and government attitudes and their interactions. No attempt will be made to include all the data and treatments contained in this comprehensive information-packed report, but the serious reader is urged to consult this work. The authors have included some data (Table 3) which indicate the losses (and gains) encountered in using different rice milling combinations.

In these studies, results from the commercial milling tests showed the highest total milling recoveries for mills using rubber-roll hullers (Table 3). Disc-cone and steel hullers followed in that order. This finding is based on the mean performance of each mill type. Close examination of total milling recoveries for two cone-type units showed recoveries of 71 and 70 percent which were slightly higher than was obtained from the rubber-roll hullers. A similar condition was also noted for one steel huller which had a total milling recovery of 67 percent which is comparable to the output obtained from the cone-type mills.

Systems employing multipass milling (as exemplified by one Satake and the cone-type units) obtained higher head rice recoveries--ranging from 72 to 78 percent--compared to systems using single pass milling (as exemplified by the steel huller) and the stone disc-steel huller combination. The difference in head rice recovery in multipass milling can be attributed to the fact that grains are subjected to less pressure during the whitening process and removal of the bran. In single-pass milling, the grain is under high pressure with concurrently higher temperatures which results in excessive breakage. Moreover, the mixture of unhulled paddy with the rice increases frictional forces resulting in further breakage.

Among the six alternative milling technologies tested, the steel-huller mill gave the lower total and head rice recovery. However, when the steel-huller is used as a whitener in combination with a rubber-roll or stone-disc huller, significantly higher total and head rice recoveries were obtained.

IRRI has determined that replacement of rubber rolls is the largest element in variable production costs for installations using rubber roll equipment.

The estimated cost breakdowns for IRRI-designed equipment for village level rice production and processing operations are listed in Tables 4 and 5. The number of machines actually manufactured and adopted in different countries are listed in Table 6.

Institutions/Organizations

1. The International Rice Research Institute (IRRI) is generally recognized as the foremost rice research center in the world. It is financed by grants from many private foundations, government agencies and international organizations. While the majority of the research effort is concentrated upon agronomic aspects of rice production, considerable effort has been expended upon postharvest rice practices and improvements. Numerous documents attest to the importance and contributions of this organization. Their developments and extension work are encountered in all developing countries as noted throughout this report. Note: IRRI informed the authors (1978) that efforts directed toward reducing rice postharvest losses during processing was about to be reduced and possibly terminated.

2. A lesser-known organization is the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). It is part of the Southeast Asia Ministers of Education Organization (SEMEO). Its fields of interest are largely socio-economic, community operation, production and marketing. Its purpose is to train and educate, conduct short courses and workshops of the "lift yourself by your bootstraps" philosophy. It is an administrative umbrella to handle programs funded by sources interested in specific programs. Principal backers are:

   (a) IDRC--International Development Research Center (Canada)
   (b) CIDA--Canadian International Development Agency
   (c) USAID--United States Agency for International Development

   Staff Member H. van Ruiten is supported by the Netherlands government.

   The specific program is the Southeast Asia Cooperative Post-Harvest Program which encompasses:

   1. Drying activities such as a recent short course in Indonesia.
   2. Workshops such as two held in Bangkok.
   3. Traders' and millers' seminars.
   4. Extension work with technicians and supervisors.
   5. Working with research people on development.

   They do not conduct research but consult with people who are developing equipment and systems.

Most training efforts publicized in the Philippines are centered around IRRI and are concerned primarily with international effects. Various workshops

Table 3. Comparative Rice Milling Tests

Milling System	Actual capacity (kgs/hr)	Commercial milling[1]				Laboratory milling			
		Milling recovery	Head rice	Broken rice	Brewer's rice	Milling recovery	Head rice	Broken rice	Brewer's rice
		Percent							
Rubber roll single pass (Kyowa)	225	69.75	60.55	38.50	0.95	72.65	82.94	14.97	2.09
Rubber roll multipass (Satake)	4200	69.43	77.71	21.94	0.35	71.33	80.00	17.25	2.75
Rubber roll kiskisan combination	300	68.47	59.05	40.50	0.45	71.31	86.07	11.50	2.43
Cono[2]	630	68.36	74.55	24.61	0.84	70.90	80.22	17.37	2.41
Stone disc kiskisan combination	444	65.56	53.68	43.63	2.69	68.80	80.00	17.67	2.33
Kiskisan[2]	380	64.50	29.18	68.86	2.06	72.29	81.19	16.45	2.36

1 Tests for each milling system were replicated four times (4x).

2 Average values from four different mills.

Table 4. Estimated manufacturing cost breakdown of IRRI-designed machines

Machine	Direct Labor Cost (1)	Mfg. Overhead Cost (2)	Total DL & OH[1] Cost (3) = (1) + (2)	Material Cost Fabricated (4)	Material Cost Purchased[2] (5)	Total Material Cost (6) = (4) + (5)	Total Mfg. Cost (7) = (3) + (6)
Axial Flow Thresher with Rotary Screen	569.58	854. 37	1,423.95	1,796.17	1,487.50	3,283.67	4,707.62
Axial Flow Thresher with Oscillating Tray	490.44	735.66	1,226.10	1,366.43	1,250.18	2,616.61	3,842.71
Portable Thresher	136.54	204.81	341.35	697.65	271.65	969.30	1,310.65
One-ton Batch Dryer	169.34	254.01	423.35	1,231.32	474.89	1,706.21	2,129.56
Grain Cleaner	267.44	401.16	668.60	446.80	738.00	1,184.80	1,853.40
5-7 Hp Power Tiller	204.42	306.63	511.05	278.07	863.01	1,141.08	1,652.13
Diaphragm Pump	37.98	56.97	94.95	151.20	24.36	175.56	270.51
Liquid Injector	9.90	14.85	24.75	24.70	28.20	52.90	77.65

US$1.00 = 7.35

[1] Direct labor and overhead cost

[2] Excluding engine cost

IRRI Semiannual Progress Report #23, 7/1/76 to 12/31/76
Rice Machinery Development and Industrial Development Ag. Eng. Dept.
1. Note: Column 7 is in pesos.
2. Note: One-ton batch dryer is the flat bed dryer.

organized by SEARCA, FAO, and UNIDO are internationally oriented and only use a Philippine orientation because of the activity surrounding IRRI.

Domestic programs are initiated by different campuses of the University of the Philippines, Los Banos (UPLB) and the Philippine Rural Reconstruction Movement (PRRM). FAO has supported INSAET at UPLB in the development of a training center for technicians concerned with rice milling, this being used for both domestic and foreign students.

PRRM disseminates software technology. It teaches extension workers how to teach; they already know what to teach. The barrio lacks management capability most. PRRM is a charity organization with management funds from the Philippines internally and project funds from outside sources. It is 26 years old and appears healthy.

One assessment offered was that Philippine extension services do not pay enough to be viable in impact. An effective extension service is possible only if it is well staffed and supported as a career establishment.

Current Projects in the Philippines

1. A total of 58 grain centers is targeted to be established at national, regional and provincial levels. Five centers are now operational. The grain centers will serve as a training ground for postharvest technology and storage operations for the private sector, both farmers and trader/processors.

2. Applied reserach and industry development studies on postharvest operations, marketing and distribution including an extension program of the government aims to enhance the integrated development of the rice industry through transfer of technology to all sectors, farmers, processors, distributors and investors. These beneficiaries of the training program of the government are considered as leaders in their respective field of endeavor. Thus, a high multiplier effect of the transferred technology is expected.

3. Projects under way at the Institute of Agriculture Engineering Technology (INSAET-UPLB):

   a. Land and water resource engineering
   b. Agro meteorology
   c. Farm machinery
   d. Department of agricultural processing

      1. Grains processing division, including milling and testing
      2. Horticultural crops processing
      3. Food engineering department.

   The Grains division was started in 1964 by De Padua. In 1970, FAO-UNDP supported the setting up of laboratories for milling and testing and initiated rice processing, training technicians for 3 years. Since 1973, funding has been mainly by the Philippine government who have carried on training for technicians or middle management.

In 1976, IDRC provided funding for research work on milling, drying, and handling. These studies included small milling systems, rubber rolls and Engelberg mills following the Bicol system of study, work on predrying and handling by aeration, and different milling parameters to determine what is optimum polishing, best method of operating the rice mills, how many whitening passes are needed and the best combinations of rubber and roll cones.

In 1977, IRRI-USAID funded work on estimation of losses (BICOL); INSEAT participation was at the milling level. In 1978, IBRD (International Bank Reconstruction and Development) (World Bank) provided $300,000 for estimation of losses project of 2 years' duration. The project includes identification of losses, recommendations, testing theory, modifying theoretical approach and includes insect and rodent control. The project members include engineers and economists.

4. The World Bank Project on grain processing and storage provides loans of $14.3 million with the provision for $11.5 million more later including the $300,000 earmarked for research on losses (3, above). Under this program, developments expect to include 360-400 grain processing mills with storage and is oriented towards the private sector.

5. In-House Projects of NGA include design and development of a centrifugal rice huller; comprehensive study on the use of rubber roll husker; further study on milling recovery of cono rice mills in correlation to physical characteristics of paddy; evaluation and value analysis of the UP-IRRI flatbed driers; and rice mill evaluation programs.

<u>Projects Contemplated</u>

1. The FAO has advanced plans for two projects:

    a. $163,500 for assistance for establishment of improved small-scale parboiling and milling units for reduction of processing losses;

    b. $170,600 for provision of processing and storage facilities for strengthening of the small farmer development program in order to minimize food losses.

2. The establishment of a postharvest institute for grains was ordered by Presidential decree, May 24, 1978, creating authority. NGA drafted the decree. The heads of UP and NGA are on the Board of Trustees. The set up is to do research and extension work in a more specialized manner and to strengthen existing work by universities and institutions. The Board would like to extend into regional services, to set up research, development and training. De Padua will be director and will coordinate with other schools in the country and in other countries. The Institute will give scientists and inventors assistance in helping on their own inventions, and intends to improve private sector rice mills, and to refine postharvest practices to increase efficiency and decrease losses.

3. A project to support industries to locally manufacture moisture meters has been contracted to the (government) metal institute.

INDONESIA

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	8508	8765	8750	8200	8800
Yield - MT/ha	2.64	2.57	2.59	2.78	2.96
Production - ThMT	22463	22560	22647	22794	26029
Milled - ThMT	14607	15452	16252	15845	
Imports - ThMT	1990	1859	625	225	
Consumption Kg/Cap	114	119	121	120	
Production Kg/Cap	108	116	119		

Rice is the staple food of the majority of the 140 million people. Rice is grown in all provinces of Indonesia, generally on irrigated land.

The pattern of production is basically traditional, but it is in the process of changing. Many areas still use the traditional way of ploughing. Harvesting is done manually by hand both with a sickle and with a small knife called "ani-ani." The moisture content of the paddy is 20-25%. The planting season in Indonesia varies from province to province, depending on the rainfall, and the harvesting season also varies. One reason why extensive use of harvesting and planting machinery is difficult to introduce is because of the small farm size (average 0.5 ha per farmer, 50% of the farmers own 0.3 ha) owned by individual farmers. The people are not concerned with the percentage of brokens in their milled rice. Parboiling has been tried but lacks acceptance because of taste and color. Indonesian rice farmers are at the subsistence and semisubsistence level and sell a low percentage of their rice from their farm. Less than 10% of the farmers belong to cooperatives.

The building of new roads, improvement of the old roads, the increasing number of trucks, especially the light utility vehicles, has improved the transportation facilities in the rural areas. Local transportation and transport of agricultural commodities from its production centers to the cities now is much better, compared with conditions even a few years ago. Such improvement has helped to reduce losses, cut marketing costs and improved the farmers' income.

There have been a number of studies showing a range of rice postharvest losses. The most recent study has been done at Gadjah Mada University, Yogyakarta. They have done the basic research and surveys of the actual losses under field and processing conditions. The comparative performance of milling systems is covered in an excellent fashion in a paper published by Suhargo (in Indonesian).

Two different estimates were derived from the fixed percentage method and a BULOG (The National Logistics Body) survey funded by USAID, "Rice storage handling and marketing study," 1971. The differences are substantial, and the Government considered BULOG figures too high. It has been suggested that harvest and transportation losses are recovered by scavenging animals and eventually reenter the human food chain.

A comparison of the various studies show:

	USAID BULOG 1971	FAO BULOG 1971/72	FAO 1977
Harvest	8.0	8.0	--
Threshing	-	-	4
Drying	2.0	2.0	2
Storage	5.0		2
Farm	-	4.0	-
Mill	-	1.0	-
Milling	4.5	4.5	2-4.5
All Transport	5.5		
Field Transport	2.0		
Dryer to Warehouse	1.5		
Warehouse/Market	1.0		
Hook loss	1.0		

Five to 10 percent (1 MMT in 1975) of total rice and paddy consumption is stored and distributed by BULOG with estimated losses (defined as "waste") from 1968 to 1973 respectively of: 75; 72; 39; 30; 35; 60 thousand tons; (ca 6 percent in 1973).

It is believed that Indonesian milling was 20 percent mechanized in 1968, 60 percent in 1975. (This is a disputed figure based on 5 percent hand-pounding outside Java and 30 percent handpounding in Java). In addition, there has been a gradual phasing out of large rice mills in favor of small rice hullers and/or rice mill units, as part of the scheme to strengthen village cooperatives.

Indonesia is conducting a "save the grain" campaign. The key input needs to be threshers and dryers. Development and extension work needs upgrading and intensification because of the critical requirement to introduce the concepts and hardware at the farm level.

Threshing

In Indonesia, new rice varieties and multiple cropping are being introduced as water is made available for irrigation throughout the year. The traditional rice harvesting technique consists of cutting each stalk about 20 cm below the head. The short-stemmed stalks are then accumulated in one hand and then bound into small bundles about 8 inches in diameter. The small bundles are immediately transported away from the field for further sun-drying, stacking and eventual threshing as needed. The indigenous varieties are commonly left standing some time after maturity for natural drying prior to harvest, so follow-up stalk paddy drying has not been too critical. Inasmuch as Indonesian rice farmers have traditionally marketed their surplus rice in the stalk rice bundle form, threshing has not been an operation of concern as their consumed rice has been threshed mainly by hand-beating. The advent of the new higher yielding rice varieties with the associated shattering makes the traditional handling of stalk rice unacceptable. Field threshing is

necessary, usually by beating, sometimes on plastic sheets. These varieties shatter badly and have to be handled very carefully. Threshing methods in use include:

1) Beating on threshing frame.
2) Beating or flailing with an object.
3) Manual treading (mostly by women).
4) Pedal thresher (usually Taiwanese).
5) Table thresher (IRRI).
6) New IRRI threshers in introduction.

It is represented that the crop mix is 40% traditional varieties and 60% high-yielding varieties (HYVs) with the older varieties priced at a 10-20% premium. The older commercial method in which the medium traded was stalked paddy saw the rice miller with a stationary mechanical thresher at the mill but now this thresher is not used as the majority of the paddy is traded by the farmer/ middleman as threshed grain.

Current efforts at introducing threshers include the Ministry of Agriculture operated farm in Tami Makmur. Under a bilateral agreement with the Government of Japan, various Japanese equipment (combines, double drum thresher, pedal threshers) has been introduced to the surrounding cooperating farmers. BULOG has undertaken the modification of the Japanese drum thresher and manufactured several units for distribution.

IRRI has mounted an active campaign of development and introduction of its axial flow and portable models. It is not known if the penetration has been further than the ones noticed at various experiment stations.

A manufacturer in central Java (Tegal) is building pedal threshers in small numbers. Some of these have been purchased by the Department of Transmigration for use in Sumatra and South Salawesi where there is not the surplus labor available on the farm. It is said that a man can operate a pedal thresher for at least 5 hours at a production rate of about 50 Kg/hr. On Bali the custom thresher contractor has shifted his focus to powered mechanical threshers.

Parboiling

There seems to be no evidence of parboiling in Indonesia. They have tried parboiling but have had no acceptance because they dislike the taste and color.

Milling

Rice milling in Indonesia has changed greatly in the past ten years. From a 80/20 bias in favor of handpounding, more farmers are now having their rice machine-milled. Today, the ratio is 20/80 in favor of the mechanized version.

The First Five Years Development Plan started in 1969 encouraged investment in the rice milling business. The import of small, compact but efficient Japanese machinery showed that building small rice mills (SRM) was a profit-

able village enterprise. Along with the increase of paddy production by the acceptance of HYVs, the number of SRMs increased rapidly. During 1969-74, more than 12,000 SRMs were installed.

After 1974 the problem became different. Too many SRMs had been built competing with each other to acquire the necessary supply of paddy. The milling fee was forced down to a point that may not always be enough to break even. Restrictions on new SRMs has been initiated by the government to prevent additional competition. The small rice mill business is much less profitable than it was in 1970/71.

Situation of Rice Milling Industry in Indonesia, 1968 and 1974

Year	Large Rice Mill	Small Rice Mill	Total Milling Capacity (A) Ton/Year (200 days)	Total Rice Production (B) (Ton)	Percentage (A/B)
1968	700±	7,000±	2,400,000±	11,667,000	22%
1974	1,144±	28,000±	13,503,000±	15,275,000	95%

Source: Directorate General of Food Crops.

Notes:
1. Rice mills in 1974 generally equipped with better machines, gave better quality of rice, better milling output.
2. Average milling capacity of big rice mill: 7.5 ton of rice/day. Small rice mill: 2.5 ton of rice/day.

There are still remaining in Indonesia operating traditional mills built in the 1920's (and earlier). These cannot compete with the newer SRMs because the system has changed wherein they cannot physically acquire the quantities of paddy (or stalk paddy) to profitably operate. In contradiction, a great deal of the tonnage milled by the large rice mills is for BULOG on a custom basis. But, the government through the Ministry of Agriculture and BULOG are introducing small Japanese mills for the farmer cooperatives - the BUUDs. The two levels of milling sophistication are (1) a simple rubber roll-husker and a one stage horizontal whitener-polisher; (2) adding a separator, and substituting two stage whitening. Incorporating milling as part of the activity of the BUUD allows the farmer to participate in the profits of milling his production. It is their concept to start with the simple mill to acquaint the farmers with the technology and philosophy of milling. There is, however, a problem here. The simple Japanese mill performance may not be better than the steel huller, used at present, and it is less durable.

The Indonesian plan is that their program for the farmer cooperatives embraces not only production, but includes processing, and marketing. The buffer stock of the BULOG is produced from the BUUD rice mills. This is academic since the BUUD's do not have the milling capability and so the BUUD's contract with private millers and pay a milling fee of 6 to 10% of the milled rice in kind.

About 10% (2000) of the cooperatives have SRMs and 3 or 4 in West Java operate large rice mills. The typical BUUD comprises 600/1000 ha and requires a 1/2 TPH or 1 TPH mill.

The moratorium on additional rice mills is the result of totally uncontrolled siting and economics concerning the SRMs. Traditionally, the hand-pounding milling was done by women. The spread of SRMs to every village has caused serious social dislocations and forced transfer of the displaced labor to other activities.

Drying

Sun drying is the least expensive way to dry rice in Indonesia. (1 Rs/Kg for sun vs. 3.5 Rs/Kg for mechanical). There is no commercial manufacture or widespread use of driers in the country. All driers existing in the country are the result of a government program or assistance by an outside agency. Stalk paddy is dried on cement drying floors (in the rice mill) or on the ground in front of the farmers' houses. The HYVs wet grain need to be dried on a cement drying floor or with a certain ground cover (bamboo carpet, plastics) to prevent losses due to shattering.

Stalk paddy at the time of harvest has a grain moisture of about 20-25%. The bundles are sun dried then hauled to the villages, at which time the grain moisture would be 18-20%. Another day of drying would bring it down to 14-15%, after which it is stored in open sheds, or in the open in pyramidical shape until the bundles are brought inside the rice mill.

Mechanical drying is considered expensive and unattainable by common farmers. Between 1970 - 1973 many large rice mills bought driers for their own purpose. Many models and type of driers were imported to Indonesia. Most suitable for Indonesian conditions was the British Lister dryer (flat-batch type). Only the large rice mills could use this type of dryer, since it needs 15 tons of paddy (at least) for one batch of drying. For the farmers' use the Directorate General of Food Crops is encouraging the IRRI model, flatbatch type drier, with 1- 1/2 ton capacity. The governmental strategy in introducing driers is through the BUUD at the village level. New IRRI rice varieties have a short maturing period, and the harvesting time for IR28 and IR30 occurs at the peak of the rainy season. At such times the flat batch mechanical drier can show its importance in saving losses. Mechanical driers in Indonesia by date include:

1968 - 40 Lister (flat-batch) 23MT/24 hrs; has worked well.
1969 - 300 Flat Bed. 0.6 to 1.0 MT/hr: not in use.
1969 - 80 Konskilde (Danish). 9 MT/16 hrs; not in use due to lack of spare parts, expensive, too sophisticated.
1970 - 80+ Satake Vertical Recirculating. 1 MT/hr; None functional.
1974 - 7 L.E.W. 7 MT/16 hrs; in the BUUDs.

BULOG is salvaging some of the Satake recirculating units and utilizing components and materials for farm type shallow-bed driers, for use in the BUUDs. Some BUUDs use a double box shallow bed with French "low" blower burner unit. This allows some time for tempering and coordinated loading and unloading. At Tonibun a LSU prototype model has been constructed.

Projects (Past and Present)

1. ASEAN-Australian Economic Cooperation on Food Handling Project. The Australian Government in cooperation with the five ASEAN Countries (Indonesia, Malaysia, Singapore, Thailand and the Philippines) is conducting a Food Handling project. This program includes Grain Handling and Storage. In the Department of Agriculture (Departenen Pertanian) Mr. Solmartono is the Indonesian representative in the ASEAN Food Handling project. The projects are selected according to the following criteria:

   (a) to reduce losses in quality and quantity which will give benefits to both producers and consumers.

   (b) to utilize waste for industrial purposes.

   (c) to improve and strengthen marketing facilities.

2. Other ASEAN projects include Australian technical assistance in an ASEAN context for: (a) the development of long-term processing and silo storage techniques; (b) crop losses in postharvest handling.

3. Postharvest processing investigations are being carried out at three institutions: The Institute of Technology, Bandung (ITB), the Institute Pertanian Bogor, and Gadjah Mada University, Yogyakarta.

4. The ITB Agricultural Engineering Department, in cooperation with NUFFIC, a consortium of Dutch Universities (Ing. R. Bertus V. Heugten, advisor), is studying:

   (a) Thresher development - pedal operated using bicycle frame.

   (b) Refrigeration - absorption type using bio gas (husk) or solar heat.

   (c) Drier - box flat bed type with husk furnace and cement (rhash) walls.

   (d) Drier - vertical box type with solar and husk fired indirect furnace.

5. The ITB Chemical Engineering Department (Dr. Sasmojo) is studying:

   (a) Pyrolysis of rice husk (AID)

   (b) Ferro cement technology (AID)

   (c) IRRI Flat Bed Type Dryer

6. Since October 1976 BULOG, assisted by the Tropical Products Institute-UK, has arranged two storage trials. One test and quality control within the BULOG procurement, storage and distribution system, and the other one a full scale trial of on-floor storage and deep bed drying for bulk paddy.

   Three TPI experts are working at the BULOG Rice Research Center in Tambun, West Java: Mr. J. A. Farlane (Team Leader/Biologist; Mr. A. D. Gracey (Storage Engineer); Mr. M. T. Locke (Training Specialist).

7. In 1970 Dr. Toshizo Ban from the Japanese Overseas Technical Cooperation Agency led a mission to study the rice mill situation.

8. Since October 1975 BULOG with IDRC have had a joint project on post-harvest technology. A Canadian expert, Mr. James Bryan, was working at the BULOG Rice Research Center-Tambun before his death in 1978. Grain handling in farm level operations was considered initially, through the project will reduce to only drying in the future.

9. In 1968 a mission from the Tropical Products Institute-UK visited Indonesia to study the rice milling situation. The two member mission (Dr. Kirby and Mr. Adair) traveled West Java and Lampung provinces and made recommendations for the improvement of Indonesian rice milling.

10. In 1970-1971, a five member mission sponsored by AID studied intensely the problems of rice handling, storage and marketing in Indonesia. This mission stayed for 6 months, traveled to the important rice producing and marketing areas and produced numerous recommendations on the problems.

11. In 1974 FAO-UNDP commissioned a task force (73/02-01) to investigate and report on conditions of rice grading, storage and processing in Indonesia. Members were Thet Zin, Gariboldi, Hawkey and Ellis. It is believed that today's conditions are close to the situation covered in in this report.

12. Another project is reported here but no definitive information is available. Quote "An attempt at an integrated complex was halted at the foundation stage in Krawang, West Java. It consists of a threshing plant for stalk paddy, an American continuous flow dryer with tempering bins, 2 corrugated sheet metal silos, and a Japanese Yanmar 1-ton per hour mill. It looked like all the components were in the warehouse, but that some difficulties arose in the financing. The USAID handshake trademark was stamped on the American equipment. This is a pity, for the complex is in the middle of a vast rice growing area that is fully irrigated." (D. DePadua, private communication)

13. The FAO 1978 survey of post harvest reduction of losses programs; members of the team were von Hulst and Thet Zin. The recommendations for suitable projects include $226,400 for a pilot program for improvement of handling, storage and processing facilities in village unit cooperative-South Sulawesi; and $377,000 for development and training in postharvest technology through the rice processing center in Tambun.

14. A pyrolysis project under AID appropriate technology contract to adapt to local situation. Funding $500,000, 2 year grant with, $100,000, 2 year follow-up for dissemination of first project.

15. It is contemplated that projects will be authorized to develop definitive loss assessment programs and comprehensive evaluation of relative efficiency of rice milling methods.

16. No details are known on FAO projects INS/74/025 - strengthening or rice processing center, Tambun (BULOG) for the prevention of losses in national stock-pile operation.

17. ITB Mechanical Engineering Department, (Dr. Harahap).

    (a) Mechanization - studying existing machines, and trying to build better models.

    (b) IRRI project to carry out milling tests on 2 ton louvered drier.

18. United Kingdom (Hawkey) Project at BULOG Rice Processing Research Center at Tambun, concerns threshing, drying, storage and milling. The project is sized for a BUUD village complex harvesting about 800 ha. A new technology husker/polisher (designed by Tainsh & Bursey) and built by Christie & Norris-UK is included along with an Alvin Blanch (UK) drier fueled by an innovative air suspended cyclonic type husk furnace. The mill is rated at 500 Kg/hr and the drier a 7 TPH used as a three pass. The focus of this project is to develop systems that are capable of local manufacture and operation.

<u>Training</u>

Training of technicians and personnel in Indonesia is on a fragmented basis and limited in extent when one realizes that this is a country of 130 million people. There seemed to be a small formal training activity both in the Department of Agriculture and in BULOG. In the Department of Agriculture, they perform testing of all equipment in the post harvest field from land preparation to milling, and all extension work. The office is the counterpart of IRRI. They use several hundred people in the provincial governments and have trained about 500 people in extension work. A yearly retraining activity updates individuals' skills.

BULOG does some personnel training at its Tambun Center and wishes to strengthen its activities, particularly in the aspects of standards and grading.

Many of the junior staff personnel from the Department of Agriculture, BULOG and the Cooperatives were trained abroad under AID, FAO, IRRI, TPI, and other agency sponsorship, or under international exchange programs.

SRI LANKA

General

	1973/74	1974/75	1975/76	1976/77	1977/78
Area - Thha	672	681	525	500	740
Yield - MT/ha	1.95	2.36	2.15	2.32	2.39
Production - ThMT	1312	1606	1100	1160	1765
Milled - ThMT	892	1092	748		
Imports - ThMT	340	300	400	500	
Consumption - Kg/Cap	96	89	89		
Product - Kg/Cap	67	78	46		

According to the rainfall pattern of Sri Lanka, the cultivation year (except in the wet zone constant cropping areas) can be divided into two distinct seasons; namely, Maha and Yala. Cultivation during the Maha season takes place between October and March; whereas, the Yala cultivation is done between April and September. Harvesting of the Maha crop extends from January to April with a peak collection in March and April. Yala cultivation, which is done with the help of supplementary irrigation, is harvested July to September.

The purchasing and milling of paddy in Sri Lanka is vested in a government organization, the Paddy Marketing Board (PMB). It is the monopoly buyer of paddy as well as the sole authority in the milling and marketing of rice. There is an organization to execute the Board's functions, and in this the cooperative societies and private millers play an important role. Paddy offered for sale is purchased by the various purchasing centers operated by the cooperative societies that act as agents of the PMB. Quotas of paddy are issued to the PMB mills and private mills, which do the milling for the Board on a contract basis.

There are about 4500 paddy purchasing centers scattered throughout the country, and these centers, which are managed by cooperative societies and a few cultivation committees, purchase paddy from the farmers. The government of Sri Lanka offers a guaranteed price for paddy, and this money is paid to the farmers at the time of acceptance of the paddy. All authorized agents who operate the paddy purchasing centers grade the paddy at the time it is purchased from the farmers.

The IRRI-PMB assistance project has over the past years attempted to perform a rational improvement of the manufacturing capacity of the country, the management and physical plant of PMB and the position and physical plant of the private sector. The project has involved itself in the marketing aspects of the industry, improved the procurement status and the quality of the products. The existence of the current AID assistance plan and its implementation is a direct result of the project's influence and direction. The project and the industry today in Sri Lanka reflect the policies and efforts of the director, James E. Wimberly. Details of the projects are obtainable through various publications in AID files.

In procurement and marketing, inadequate rice grades and standards, lack of quality control at all levels and insufficient policing of marketing practices

allow poor quality rice to be sold at disproportionately high prices and result in large losses to the farmer and the consumer. The background reason is the widespread existence of mixed varieties. Until production practices are improved with pure seed and adequate management the mixed variety problem will render impossible improvement even in rudimentary milling efficiencies. Regardless of the public position, the private trader maintains a differential for moisture, dockage and varietal purity.

Losses

Traditionally the various steps in post-production practices in Sri have lacked coordination. Each phase was handled as a separate entity operating independently, resulting in underutilized facilities and over-burdened apparatus, poorly managed labor pools, and other costly and wasteful practices.

The PMB/IRRI team has estimated that paddy losses totalled between 25 and 30% of the total national paddy production of the country. The range of losses in individual process areas were stated to be:

Threshing	-	2-6%
Handling	-	2-7%
Drying	-	1-5%
Parboiling	-	1-3%
Milling	-	1-6%
Field Drying	-	1-15%

Several comprehensive loss studies of specific areas have been accomplished. The focus has been on the PMB in this improvement but also it must be remembered that the village level post harvest activities account for over 70% of the rice handled in the country. Most of the losses in the government sector can be traced to inefficiency in management. There is no incentive in the present system. The Department of Agriculture is primarily interested in the improvement of the situation for the small farmer.

Threshing

Threshing is done manually or by animal or tractor treading. These systems yield poor quality paddy with excess dockage (stems, dirt and debris). Only a few threshers on test were seen in Sri Lanka. The Department of Agriculture Farm Machinery testing station at Maha Illoppallama has tested IRRI designs for about 5 years. This testing, however, has not been done to show the labor advantage or cost of mechanical threshing over treading. The government factory at Welisara built 10 machines for test. The foot pedal thresher has been evaluated and introduced in a very small way but has not been widely adopted. Promotion of the machines and subsequent extension efforts is lacking. Mechanical threshers could be introduced in large quantities in Sri Lanka if they were simple and locally manufactured. Threshing currently demands a lot of labor and farmers find it difficult to find labor at threshing time. The farmer himself feels that this is a major constraint to increased production. Most of the paddy farms in the country are very small. Any thresher, to have widespread adoption, must be of such design, construction and cost that the farmer can operate on his own.

In Sri Lanka there are two entirely different situations. One in the wet zone, and one in the dry zone. The introduction and adoption of mechanical threshing finds a totally different approach in the two zones and a middling one in the intermediate zone and an additional set of parameters in the irrigated areas. The Mahaweli Ganga Authority has shown interest in acquisition of 50 IRRI Axial Flow threshers from India. The adoption of mechanical threshing, along with improved drying capability probably would do more to increase production than anything else for the money invested. All levels of the industry were enthusiastic about the potential for mechanical threshing.

Since threshing is primarily of treaded production (man, animal or tractor), the amount of accompanying debris is large. Therefore, there is a great requirement for adequate cleaning before storage or processing. The presence of rocks, dirt, straw, leaves and such in the paddy creates operational problems in every phase, as well as the cost to transport and handle a quantity that contributes no value to the product. Sri Lanka has one peculiarity that makes this dockage problem acute. For many reasons the small 6" (Kyowa copies) rubber roll husker is used extensively, either ahead of a steel huller or as in many private mills, alone. Because of the government imposed 71% yield rule the miller is reluctant to remove anything, so debris goes through the machine. The IRRI/PMB project at an early stage recognized this problem and in order to alleviate the condition has encouraged the installation of rudimentary cleaners at procurement stations. This, along with the occasional installation of moisture meters and dryers at this point, improves the situation throughout the processing chain. The removal of the dockage at this point helps the condition in drying and storage and really helps the miller meet his 71% rule requirements without returning all of the dirt and rocks back in the milled rice.

The machinery manufacturers in Sri Lanka have built several models of pre-cleaners and milling pre-cleaners of varying degrees of sophistication. A late model type built by Deerasekera is installed in his new rice mill in Anuradhapura. It is an eccentricless two deck pre-cleaner, 3'x 5' with a 3 MT/hr input of rough paddy. Completely locally fabricated, it sells for 27,500 Rs.

Other manufacturers build varying styles (usually simpler at lower prices) to the customers design. All that is necessary for their introduction is to provide the incentives to allow the production of clean paddy to be worthwhile. At the present time the farmer feels that it is to his detriment to deliver clean paddy--or to have it cleaned at the delivery point because the weight loss is for his account. This is primarily true unless the pricing and grading system is changed to accomodate the necessary penalties for delivery of wet and dirty paddy based on a realistic level. This fact has been brought out by consultants, but the Government has not yet provided the leadership necessary.

Drying

Most paddy in Sri Lanka is sun-dried, either as raw paddy which has been harvested in wet times with high moisture, or which has been rained on and rewetted unavoidably, or as parboiled paddy before milling.

A major problem facing dryer adoption is the cost of fuel. In Sri Lanka there are three indigenous potentials; rice straw, rice husk and coconut waste (husk or coir dust), which are acceptable fuels and satisfactory technology is available for implementation. What is needed is a program of introduction and extension.

In the IRRI-PMB project the installation of dryers at the procurement level is an integral part. This is a most exemplary program and it is hoped that the supervision and extension efforts will enable these dryers to operate at their highest efficiency and that the management practices will encourage their full utilization.

In Sri Lanka a number of LSU type vertical dryers have been installed at the PMB complexes, as a result of design urging by IRRI-PMB project personnel. In some of the older mills (European style) vertical dryers using steam heat exchangers are installed and are used usually on parboiled rice. Throughout the country cascade type (Alvin Blanch) driers are found in isolated installations. These were not designed for parboiled rice, and are high fuel cost machines. In some places they are only operational when bad weather precludes sun-drying. Box driers are being installed at the procurement centers and a few are elsewhere in use. A new type of cascade drier was inspected at Deerasekera's factory at Matara. This is a stationary masonry construction with a 4-5 MT/hr throughput. Rice residue fuel will be used.

To this time no effort has been made to encourage village level drying. Only the large scale PMB complexes and procurement centers have had dryer activity for raw paddy.

Parboiling

In Sri Lanka most parboiling is accomplished with Goya or modified Goya systems. Both are a batch system with two level water and steaming where the paddy is held on top of a perforated deck in a rectangular tank with a furnace area under the tank. One of these units will parboil about 6 MT/day. After soaking in a concrete tank, the paddy is transferred to a steaming tank. Several improved versions are under development trying to reduce the cycle time. Kettle steaming systems (Indian style) are used also. The Goya system needs no boiler and is fueled usually with rice husk or firewood thrown underneath the steaming tank. The kettle systems need steam from a boiler. The modified Goya system eliminates the chance of overcooking part of the batch. The CFTRI (Indian) system is demonstrated at the Anuradhapura center. This system uses a four hour soak and 45 minute steaming and produces a high quality product. Costs are quite variable--a boiler (Jaya) for a 2 ton parboil system, husk fired, costs 700,000 Rs. A Goya tank costs 17,000 Rs and a powered husk blower costs 7,000 Rs. Labor to manually throw the fuel in costs about 10 Rs/day.

The PMB complexes are all designed to incorporate parboiling, however, the authors were told that none of them are installed or operating. Several of the older PMB mills have parboiling systems in use.

There are several other systems under study in Sri Lanka. One is the continuous steaming process (after Kuppuswamy) and a multiple drum over and under system developed and promoted by H. I. Fernando which is under test at Anuradhapura.

There are no problems as far as parboiling technology in Sri Lanka, however, the economics are not as encouraging. The intermediate drying cost problem, particularly with the atmospheric systems discharging 50% moisture paddy, is difficult. The most beneficial improvement likely would come in a drier development using an indigenous fuel, either direct or indirect airflow. It appears that more sophisticated parboiling developments will be many years coming to Sri Lanka because of the lack of market demands for a high quality product.

Milling

Milling of rice in Sri Lanka is divided into two broad spectrums. The official sector processes about 35% of the crop and the private sector about 65%. According to PMB figures (which do not reconcile) the government mills processed somewhat less than 10% of the total and the quota (contract on PMB purchased paddy) millers processed about 25%.

The government mills comprise new with Japanese, European and local equipment, older Japanese unit mills, older yet traditional European mills and Engelberg-type steel hullers. The quota millers are generally two stage, rubber roll husker with a whitener (sometimes not used) of the small Kyowa style, vertical cone or steel huller type, but some use two stage (or one stage) steel hullers, particularly on parboil milling.

The private sector is divided into two main sections: (1) the commercially (who may be a trader) oriented miller (30% of total) who may or may not have a multi-stage, multi-unit mill; (2) the bulk (35% of total) of this sector is milled on a single steel huller in the village (locally called a grinder) mill.

The presence of precleaners or stoners of any type is not the case in the majority, although the more sophisticated PMB mills and some of the more advanced quota millers practice some degree of cleaning before milling. Grading after milling is the exception, usually a sieving and winnowing, (hand more often than mechanical) completes the milling tasks. Many of the mills have locally made paddy separators following their rubber roll husker, some with elevator transfers, more with basket transfer.

Several outstanding locally manufactured mills were being built at the time of this investigation. The variable pitch/stroke Deerasekera paddy separator (a copy of the German Schule) is present in most of these new mills along with a large V-belt rubber roll sheller instead of the small old design Kyowa copy.

Manufacture of rubber roll sheaths has been practiced in Sri Lanka for a number of years. The Japanese (Elephant Brand) replacements will, on balance, process 2000 bushels at a cost of 650 Rs where the locally made ones (Nabeesa) will do 1000 bushels at a cost of 220 Rs. There are some sizes (particularly large) which are not made in Sri Lanka.

The authors were advised that in the sector processing the bulk of the rice crop there was no substitute for the steel huller. Thus, improvement (or reduction in losses) will come mainly in modifications of that system, and training (extension) to effect better operation and maintenance of these mills.

Details of milling and processing factors can be obtained in detail from the AID report (Beagle-Mutti-MASI-1975) on the PMB project.

Projects

1. AID project 383-T-017-A Sri Lanka paddy storage and processing project is under way to improve PMB operations. It includes a portion (9%) for private miller development. (This is interesting because this sector of the industry mills almost 90% of the crop).

2. The Rice Processing Development Center at Anuradhapura is continuing its programs.

3. ESCAP (Khan) has a program to introduce appropriate tools and equipment, to furnish prototypes and designs, and to assist in development of manufacturing capabilities. This is a collaboration with IRRI at the threshing and drying level, and focuses on building up the capabilities of the National Institute (University) as a training and evaluation center.

4. CIDA has uncommitted funds available at the Department of Agriculture; a proposal to use this in construction of 8 standard rice mills supervised by PMB has been made.

5. The Democratic Republic of Germany has offered a soft line of credit for 25 mills. This is somewhat academic as PMB does not have the resources to undertake such expansion.

6. FAO has (1978) proposed three new projects:

    1. $196,900 for Pilot Project for Reduction of Post-Harvest Losses at Farm and Village Level.

    2. $148,950 for Provision of Pest Control Equipment to Carry Out an Effective Program on Pest Control for Reduction of Losses.

    3. $10,000 for Improvements in Existing Silos for Bulk Storage of Paddy.

7. IRRI collaborates on an outreach machinery testing program (at the Machinery Institute). Some testing has been done with construction of a few prototypes; German support funded ten of these prototypes.

Training

Training activities in Sri Lanka currently are centered at the Anuradhapura Rice Processing Development Center. There are efforts through the Department of Agriculture Farm Service Centers to effect extension services to the sector not able to be involved in this Center activities.

During the formative period of the PMB there was no one in Sri Lanka with any formal training in any aspect of post-production management of paddy. The IRRI-PMB project planned a training center where the PMB administrators and technical staff, managers, engineers, technical assistants and operators (mills, storage, etc.) could be trained. To begin the in-country PMB training and development programs, funds from the IRRI cooperative project allowed a number of key PMB staff members to be trained overseas in a variety of M.S. degree and study programs. These included 12 regional managers attending a one-month special management development program at the Indian Institute of Management (Ahmedabad, India). They are now in charge of the 12 PMB regional offices working with all field operations (procurement of paddy--coordinating the cooperatives that purchase rice from the farmers, transport of paddy to storage facilities and mills, operation of the PMB paddy storage units in their region and scheduling of processing with the millers).

The IRRI-PMB in-country program designed to train PMB technical staff has been successful. Some 1200 PMB personnel, including managers, engineers, technical assistants and operators have received training in paddy purchasing, cleaning, and drying, storage, processing, quality control and rice marketing.

The original training center was located near Gannoruwa. After the concept proved viable, momentum developed that culminated in the 1971 grant from UNDP that resulted in the Anuradhapura center as it is today. It serves both in the development of new and/or modified techniques of post harvest processing and in the training of managers, technicians and operators to staff the country's various levels of post harvest operations.

As per the original plan (though four years delayed) administration of the center has been handed over from FAO to the government of Sri Lanka.

INDIA

General

	73/74	74/75	75/76	76/77	77/78
Area - Th ha	38286	37922	39000	40001	40000
Yield - MT/ha	1.73	1.59	1.75	1.98	1.97
Production - ThMT	66141	60440	68318	79093	78829
Milled - ThMT	44050	40253	45500		
Imports - ThMT	7	100	200		
Exports - ThMT	30	40	30		
Consumption - Kg/Cap	70	65	67		
Production - Kg/Cap	73	64	71		

(USDA figures: in some years, these differ from published Indian figures by as much as 20 percent.)

India is a very large country with definite differences in conditions and needs in each of the major areas. In contrast to many developing countries which can be characterized as lacking development, India must be characterized as having development but having also tremendous problems which tend to thwart her attainment of the degree of progress which would ordinarily flow from her development efforts. The pressure of climate, population, fragmenting history and languages, competition from biological organisms, and a host of other problems, weigh heavily on individuals and institutions, pressing them toward failure, urging them to give up. But patient, relentless progress is being made. In fact, in the area of rice processing, especially parboiling, some of the most recent advances in knowledge have come from India. Indian workers are also investigating the whole area of village level processing, including testing of equipment now in use and designing new equipment based on original concepts. Some workers have extended their scope of operations to include other developing countries. India also manufactures rice equipment of every sort, though the quality of the more sophisticated machines is slightly below that of Japan or Taiwan. There has been a government program to "modernize" the smaller mills, and thus eliminate the smallest ones. However, at the same time, the government has given a special economic preference to the smallest mills by requiring only the larger to sell a definite quantity of their production to the government at low prices for their food programs. The result has been a proliferation of single-machine mills.

India is one of the major rice growing areas in the world. Rice is the staple food of more than half its population. India's production is a bit more than half that of China but more than 2-1/2 times that of the next largest producer, Indonesia.

Improvement in any field of endeavor in India is difficult but particularly so in the introduction of equipment or mechanization. It has been very bad politically to talk about agricultural mechanization, and the introduction of new equipment has faced almost insurmountable problems. The factor is said to be labor displacement, but what they are really talking about is the displacement of women laborers.

In the past few years, attention is being paid to quality for the first time. It used to be a hand to mouth situation, but now suddenly FCI (Food Corporation of India) is evoking standards. Rudimentary standards to be sure, but an indication of the fundamental changes in policy.

The problem of improvement is not technical but rather one of who is to get the benefit. At the present time, this is being sorted out in thousands of different actions at every level of the industry. Although the best place to improve conditions to benefit the most people is at the village level, most postharvest improvement projects and modernization have affected only the commercially oriented sector and a few government or cooperative-owned modern mills. Of the 70 or 80 thousand village level processors, very little has been done. In fact, very little is known about what needs to be done, for example, schedules showing the quantities milled at various levels and how really the capacity is utilized. The commercial sector is well organized and somewhat cohesive (in specific areas), but the lower levels of processing are somewhat of a mystery. About all that is really known generally is from the government licensing procedures and that is primarily a numerical exercise.

Government regulations exist calling upon the village miller to improve his husking capability, but the conversion is proceeding slowly, and whether, on balance, the newer systems, as introduced, really are beneficial is not quite clear. There is no question that something needs to be done to improve all levels of processing, but there is no agreement about what to do, nor how to do it.

Most of the emphasis in India seems to have been on milling techniques and machinery. The inclusion of improved village level threshing, cleaning and drying systems seems to have been secondary. While it is acknowledged that the conditions in India vary greatly, it would seem that tremendous improvement in reduction of losses (including constraints to planting) could be made in those fields. There has been interest in dryer development but usually in a parboiling context. The idea of raw paddy drying is as hard to get across in India as in any other Asian countries. The labor problem and the apparent cost of fuel tend to stymie every effort to introduce a viable mechanical program. Again we reach the almost impossible situation of trying to explain the added value concept. Never has there been a project initiated which thought this problem through and acted upon the necessary developments and extension to insure success. This is the greatest opportunity in India as well as the rest of Asia.

The commercial sector in India is quite viable and dynamic. They have adopted new technology in every economic situation and have progressed steadily on improvement in their milling practices. Their problems, naturally, are economic. It is a matter of incentives and profit potential.

When in the late fifties the millers became aware of the possibilities of the use of rubber roll sheller systems and of the extraction of rice bran oil, they were quick to incorporate these features into their mills. They have made considerable progress in parboiling systems with both CFTRI and pressure parboiling being used in their modernization efforts.

But at the village level, there is no such incentive when utilizing present technology. At this level there is the need to develop low cost systems of a capacity to match present requirements that consume less energy but produce results comparable to the multi-stage mills. These efforts must have characteristic features that are appropriate to the village environment, not only in terms of low capital cost but in the simplicity and cost of operation and maintenance. Some recent innovations in processing technology at the village level offer promise of improvement, if properly introduced and encouraged.

<u>Post Harvest Rice Processing Program of the Government of India (GOI) in cooperation with The Ford Foundation (FF):</u>

During the early 1960's, the GOI implemented a major food production drive primarily through an intensive agricultural development program. As the GOI-FF scientists, working with the agricultural development program, concentrated their major efforts on paddy production, they began to ask questions about the post-production industry. As a result, in 1963 a GOI-FF team began a one-year study of the post-production industry. Their report in 1964 described the industry as follows:

1. The present practices and equipment used in paddy cleaning, drying, storage and processing are obsolete, and incur substantial losses of food grains.

2. With the use of modern technology, the present systems used in post-production could be up-graded (or "modernized") in order to reduce these losses, supply a better quality of rice to the consumer, reduce operation cost, and thus supply more food grain to the nation from present production.

3. In order to adapt new technology to conditions in India and to evaluate its results, a pilot program consisting of seven new storage and processing units was proposed.

In 1965, the GOI finalized the pilot project and appropriated funds to support it. The GOI-FF team then selected locations and designs for the seven pilot units. These pilot units were located in different areas of the country so that each unit would demonstrate the operation under the various conditions of different paddy production areas. Each pilot project was to include paddy cleaning, drying, parboiling and rice milling equipment, and bulk storage facilities.

At that time, no modern equipment or facilities had been constructed in India. The GOI-FF team studied equipment used in many countries and selected the equipment to be used. The conveying equipment, cleaners, dryers and parboiling equipment were to be built locally. This called for working with local manufacturers on the designs and getting the equipment built. The bulk storage facilities selected were reinforced concrete silos to be constructed by Indian firms. This called for follow-up on civil designs and construction techniques. The only equipment imported for the pilot projects were the rice mills, which were purchased from four different international rice mill manufacturers. Later in the development of this industry, Indian firms collaborated with foreign firms to manufacture the modern rice milling machinery in

India. This provided a unique blend of technology from more developed countries and the constraints of the existing system in India. Time has since witnessed the success of this joint endeavor.

The local manufacturing and construction went through considerable "growing pains" but were later satisfactorily completed. This provided valuable experience for the Indian manufacturers and construction firms. By the late 1960's, a number of firms were producing all the modern equipment required by the post-production industry. This included all types of grain-conveying equipment, different types of paddy dryers and cleaners, parboiling and rice milling equipment, husk-fired boilers and, of course, reinforced concrete silos, as well as pre-fabricated metal silos.

As the construction phase of the pilot project was completed, the operation phase presented new problems. On-the-job technical training was conducted for the technicians and operators. Short courses were held on management aspects for the administrators. Slowly these units approached a functioning level.

At the same time, the GOI-FF team began to investigate the training and research needs of the post-production industry. After considerable investigation, it was decided to establish a "Rice Processing Engineering Center" (RPEC) attached to the Indian Institute of Technology at Kharagpur, West Bengal. The first phase of development of this center was its staff. Several were sent abroad to study other countries' programs and to develop in-country training programs and also began to undertake research and development projects. Today this center offers technical and management short courses and degree programs in the field of paddy post-production.

Another very important area in paddy post-production in India is management. As one observed the operation of the new storage and processing units, one could quickly conclude that varying degrees of success depended primarily on the management of the units. Therefore, the RPEC began to work with the Indian Institute of Management at Ahmedaban (IIMA). With this collaboration, special programs were developed for the training of managers. This proved very successful, and the demand for such trained personnel grew rapidly.

To follow through on the objectives of the pilot project, an evaluation program was conducted to determine the difference between the milling recovery of the modern rice mills and the traditional rice mills. Details of the study are reported in the Milling section. In milling raw paddy, the modern mill outturn averaged 2.5% more total rice than the disc sheller and 6.6% more than the huller mill. In parboiled paddy, the modern mill averaged 1% over the sheller mill and 1.5% over the huller and disc sheller mills. The modern mill yielded rice of superior quality, with fewer broken grains and less foreign matter.

The improved milling outturn and the economical operation favored the modern mill. Expansion of the new industry began fairly quickly, and today there are approximately 1500 modern rice mills in operation.

The rice bran produced as a by-product from the modern rice mills has become a valuable source of edible oil, which is now produced for local consumption.

Since approximately one-third of India parboils paddy, the pilot project included a new system of parboiling. Developed by the CFTRI, it consists of a hot-soaking operation followed by quick steaming. In some cases, mechanical drying is used, and in others, sun-drying. In most operations, a husk-fired boiler is used. This has been the most economical use for the husk, and saves fuel costs.

The concept of bulk storage expanded less rapidly than modern milling or parboiling. This is probably due to the two major factors:

1. Most large storage facilities in India are operated by Government sectors and not private millers, and require a large initial investment.

2. The modern concept of storage can also be applied to existing paddy stores. This is being done by up-grading the existing storage facilities, followed by use of scientific storage techniques.

Today a number of institutions are continuing activities in various phases of the post-production industry. They include the Storage Institute, RPEC, Jadavpur University, CFTRI and the Ministry of Agriculture's Department of Food Extension Division. Training programs, research and development are helping to improve the industry. The private manufacturing industry is also making a contribution of new and better equipment. The size of the country permits more firms to enter the business, and competition helps keep the prices of equipment stable.

One might conclude that India has proven the value of modern technology in the paddy post-production industry. It has made a dynamic beginning and certainly has learned much about the post-production industry. However, there still remains considerable room for improvement and expansion of modern technology throughout the country. (J. Wimberly, private communication)

Threshing

Almost all threshing of rice in India is presently done by flailing or by animal treading. The current opinion in India is that mechanical rice threshing could be introduced in the northern growing areas long before such introduction was possible in the South.

Multicrop threshers have been used in India, but investigation of their use on rice has been only academic. A few IRRI axial flow machines have been built by various manufacturers and, in some cases, are being evaluated on government farms (Hyderabad and Lucknow).

No comprehensive study has ever been made of threshing practies in India or comparative results from different types of mechanical threshers. A current project along that line is being done by Dr. K. N. Singh at UPU (Uttar Pradesh University).

A visit to Union Tractor Workshop, New Delhi, showed IRRI axial flows and IRRI portables under construction. The proprietor, Mr. Chandra, calls the IRRI portable a "Paddy Drumy" to take advantage of the reputation of the 4 million threshing machines called "drumies" operating throughout India primarily on

wheat. He also builds several models of multicrop threshers. Chandra's Union Tractor Workshop has given price quotations on 50 IRRI axial flow machines to Sri Lanka, the Mahaweli Ganga Authority (to introduce under irrigated area conditions).

IRRI has (1978) furnished designs to nine manufacturers in India. There are also several manufacturers building copies of Japanese threshers. No detail is available on these and none were seen or available. (Jyoti-Baroda and American Spring-Bombay were mentioned).

The Indian Agricultural Research Institute has been active in development and evaluation of threshers of their own design (IARI), the IRRI designs and models from Indian manufacturer's proprietary designs.

It would seem that unlimited opportunity exists in the development and introduction of threshers in India. However, before that can happen there must be a thorough understanding of the economics and social implications and a resolution of the overall benefits to their system upon adoption of mechanical threshing techniques. It is easy to see the receptiveness of the commercially oriented northern farmers, especially in the Punjab area; and conversely, to understand the reticence and resistance of the southern farmer. Only after a thorough testing and pilot project success will there be possibility of acceptance by the southern farmer.

Drying

Most paddy harvested in India is sun dried. This is accomplished mainly by leaving the paddy standing in the field until it is dried to approximately 14% moisture. In some cases this is not possible, and the paddy is harvested earlier at a higher moisture level and spread on sun drying yards and roads to permit drying to a sufficient level. Paddy that is parboiled is also sun dried on drying floors after parboiling.

Mechanical drying is popular in India in mills at the commercial level either for primary drying of parboiled or supplementary use when sun drying is not practical. More use is made of the drier if it features steam heat exchanger construction using a husk fired boiler. In some cases this is possible because of electrification of the mill so that the boiler installation which is used to drive the mill through a steam engine is now available for steam production for drier use. There has been some development on direct or indirect husk fired driers in the various development institutions but none were seen in commercial use in India. Most of these steam exchanger driers are of the LSU type, of which there are now many manufacturers in India. Some of these driers, when the need arises, are used to dry raw paddy for storage and milling.

There seems to be a suspicion and a deep rooted negativism about mechanical drying. Only in certain sections of the commerical part of the industry are mechanical drying systems accepted enthusiastically. The negativism is obvious from the situation of one Bengal rice miller:

"The West Bengal miller feels he can sun dry paddy about 300 days a year. For example, in pressure parboiling (moisture 20-22%), he has a 80,000 sq. ft. drying yard; he lays down 60 T per batch; drying takes 3-4 hours on a sunny day, 8-10 hours on cloudy days. He uses 60 laborers at 3 Rs each per day."

Drying projects underway and conceptual include:

1. Cup and cone dryer. About 108 cm diameter, it holds 950 Kg of paddy. This is a mixing dryer with hot air to be furnished from a central source. Throughput on parboiled paddy is 12 tons per 24 hour day. Total height is 715 cm, air requirement is 4000 cfm at 2-1/2" water pressure. This dryer, invented by Mr. M. Kuppuswamy, Chief Engineer of the Department of Food, Govt. of India, consists of a vertical inter-connected series of double cone frustrums each nesting in a cylindrical cup. Cones are connected at their bases to form the double cone; both cups and cones are formed from sheet metal. Rice flows down through the series of cones, in the center of which is a perforated metal cylinder that directs drying air through the grain, either parboiled or paddy rice. Air exits through the cups which remain partly full of grain. By virtue of the dryer design, the grain is both continuously mixed and subjected to varying air temperatures as it changes position during its flow. A hopper at the top, a discharge unit at the bottom, and a husk-fired furnace complete the installation. Drying air temperature is varied by mixing air from the furnace with different amounts of outside air.

   Although designed for continuous flow and a single pass, the design principle lends itself to use as a multipass continuous flow batch drier without tempering bins by recirculating grain or to multipass continuous dryer with tempering bins.

2. Parallel screen dryer holds 100 Kg of wet paddy in between two parallel screens 20 cm apart and can use screens or louvers for sides. Cost is about 500 Rs; this configuration is ideal for small lots.

3. A process for the drying of paddy by contact with common salt has been developed at the Paddy Processing Research Center, Tiruvarur. The salt withdraws the water by exosmosis. No commercial application exists yet.

4. Collaboration has been established with Colorado State University to proceed with development of mobile solar drying units.

5. Shown at Annamalai University, a square furnace using metered husk for fuel. A forced air system develops 300 cfm at right temperature to dry 3/4 TPH of parboiled paddy.

6. A 36" impingement plate furnace is installed heating a paddy drier at the FCI mill at Kuppalya. It was designed and built by Ministry of Food.

7. At Kharagpur a cyclonic type air suspended furnace replaces their step grate unit for direct heating of a paddy drier of the column type.

8. At Midnapur a LSU type steam heat exchanger drier was being installed to use in conjuction with a CFTRI parboil plant.

Parboiling

Over 65% of India's paddy is consumed as parboiled (30% processed by commercial operators). The South, West Bengal and Kerala require parboiled rice only. At the present time, there are questions by serious workers as to whether the gains of parboiling are worth the energy requirement. A major problem in the traditional thinking is the possibility that the apparent nutritional improvements in parboiled rice are nothing more than the nutrient retention because of undermilling. As yet, there have been no definitive studies conducted to balance the many factors regarding parboiling practice. There has been no question that one great advantage is the high quality of the bran when channeled to a rice bran oil extraction plant. Comparative fat contents are: raw paddy 14-18%, traditional parboiling 22%, CFTRI system 25-26%, pressure parboiling 27% fat (with a 4-6% polish). Another advantage lies in the salvaging of damaged paddy.

Originally, all households did their own parboiling, even non-farmers. The process was a matter of food preparation. Village parboiling is still rudimentary and follows a pot-to-pot system. There are a number of systems for village or household parboiling (see p. 17). In each, there is some sort of steeping or soaking and a matter of steaming, usually at atmospheric pressure. Instead of a boiler, these operations use a steamer which is simply a hot water vapor generator. In the simplest, it is a pot with a bit of water in the bottom.

In small local commercial rice mills, the paddy is soaked in concrete soaking tanks and then steamed for a short time in metal steaming kettles. In some cases, both the soaking and the steaming operations are done in used oil barrels. Very little attention is given to the quality of the rice, the parboiling is not uniform, and a mixed product results.

In some of the larger mills, a hot soaking system is sometimes used along with the metal steaming kettles. More modern ones use the CFTRI system (see p. 18) which is more efficient, and in recent years, the advent of pressure parboiling systems has brought a number of pressure installations. Different developers have added a number of modifications to the present systems.

Outline of parboiling methods in use in India:

(1) Traditional subsistence farm household method:

A pound of high moisture paddy soaked 1 hour, drained, swirled in a bowl over open flame using broom straws. Result is abbreviated parboiled product 14% moisture. (see p. 17)

(2) Traditional household parboiling for future use:

A hundred pounds of dry paddy is soaked 4 to 8 hours, transferred to a steamer, steamed until husk splits, shade dried for 3 or 4 days, and bagged. (see p. 18)

(3) Traditional village custom method:

Up to a ton of paddy is steamed a short time (optional), soaked 24 to 36 hours, steamed until husk splits, sun dried to 14% moisture, tempered overnight and milled in a huller. Result is a somewhat sour tasting parboiled product due to fermentation during the long soak. (see p. 18)

(4) CFTRI method (village or commercial scale):

Clean water is preheated to 85°C, paddy added and soaked at 70°C for 3 to 4 hours, drained, steamed until husk splits, and dried by sun or mechanical drier. The hot soak which reduced the soak time eliminates the fermentation and results in a product without objectionable off-flavors.

(5) Jadavpur University method (especially commercial):

The general procedure used is the same as the CFTRI method but with a great many detailed improvements in processing steps and equipment. Additional steps include cooling of the steamed product before drying (results in a lighter product), and tempering and slow cool down after drying. The method is continuous or batch, and the strict control and added steps results in a more uniform, improved product.

(6) Vacuum and pressure methods:

Larger commercial operators use methods similar to those used in the U. S. and elsewhere in the world. The vacuum and pressure applied at the proper times reduces the soaking and drying time, and steaming under pressure results in a uniform, amber colored product. Needless to say, pressure parboiling is a commercial level operation.

Parboil quality is a matter of local preference and traditional values. It depends on the method used (see outline above), the management of the operation, local preferences, and overall economic factors. The long, cold soak used in traditional methods allows fermentation to occur, resulting in a sour tasting product which is endured, not preferred. However, the yellow color produced by the pressure methods fetches a premium in some localities. When the market requires the lighter color, the pressure system can be operated as a CFTRI one, but with an increased drying requirement because of the higher discharge moisture of the CFTRI product. Discharge moistures are: 40-42% by traditional cold soak; 30-32% by CFTRI; and 22-24% by pressure methods. The discharge moisture determines the load on the drying facilities which in turn determines the total rate of throughput.

Several new parboiling concepts are being studied in India, each with distinct advantages.

1. Parboiling using humid hot air for soak step. A pilot plant has been in operation at Annamalai University and construction is under way on a larger plant for a Cooperative Rice Mill. Advantages are:

    a. No water in soaking cycle reduces leaching losses.
    b. No pressure boiler is necessary. Steamer or "baby boiler" used.
    c. Uses exhaust steam for heating.
    d. Energy saving, good flavor, easy milling.

2. Kisan continuous parboiler system. A pilot model was built at Kanpur. Deshikachar (CFTRI) reported on the system. Uses CFTRI method but soaking done in 12 small tanks which discharge in sequence so that steamer operates continuously. Special annular steamer can also serve as drier and can even dry other cereal grains during off season. Escaping parboil steam is used in heating water and/or for drying heat. Advantages are:

    a. Uses familiar CFTRI routine.
    b. Can be continuous or batch.
    c. Can adjust batch size to adjust throughput.
    d. Equipment is simple with low cost; energy saved.
    e. Steamer-drier versatile; off season use as drier.

3. Modified Goya system in Kerala, uses discharge from steamers for soaking. Advantage: saves energy.

4. Brine solution method. A 15% brine solution is circulated through a hot soaked batch of 45% moisture paddy (CFTRI) for 15 to 20 minutes. During steaming at 3-5 kg/cm^2 for 15-20 min, moisture reduces to 30% so that only 2 hours of mechanical drying at 90°C brings paddy to 14-16%. Advantage: very reduced drying time requirement.

5. RPEC method. Paddy is soaked in water at gelatinization temperature of the rice starch for a period which depends on the variety. Thus both soaking and heating occur in one step. The final product appears like conventional (CFTRI) parboiled but the degree of gelatinization is less, which reduces subsequent cooking time. Advantages:

    a. Single step processing; equipment savings.
    b. No boiler needed (the most expensive item).
    c. Energy saving, since no steam required.
    d. Reduced cooking time requirement of product.

6. Sodium chromate method. Oxidizing agents added to the soak water have been found effective in stopping the souring reactions in the long soak of the traditional cold soak method. Sodium chromate (.05%) is usually used though other oxidizing agents may be suitable. Advantages:

a. Improvement in product flavor.
b. Some cost reduction claimed.
c. Improves traditional method without added equipment or energy.

There are many other ideas for experimental processes being tried, and all bear watching. Some are designed to make particular use of the following general parboiling principles and facts espoused by CFTRI and other institutions that do basic research on parboiling:

1. The process is simple. Any temperature above 90°C will gelatinize the starch if moisture is present (even an air oven), and vacuum or pressure is not needed except perhaps for economic reasons.

2. The browning in the parboiling process is a Maillard reaction and is fastest (optimum) when the product is between 11 to 16% moisture. The reaction progresses at a slower rate at moistures above or below this interval. High heat, or low heat for a longer time, at that moisture results in a more intense color. Bisulfite, a known inhibitor of Maillard reactions, prevents color formation.

3. Checked (cracked) rice will be fully restored by the parboiling process. Thus previous poor handling history is not important. (but see 4)

4. Drying down to about 18% is also not critical; however, tempering must be done around 16-18% before reducing moisture further to avoid checking of the parboiled product, which results in breakage during milling.

5. Starch structure loosens during gelatinization and reassociates during slow drying in such a way that it is harder than before and requires longer rehydration and cooking time. Optimum moisture for this tight reassociation is 20%, and roasting, which drys the product through 20% quickly, is seen as a method to prevent tight reassociation and to allow a quicker cooking product. Color development is not a problem because the time is short.

Milling

Although India has many different languages and regions and the people have entirely different living systems and food practices, paddy is cultivated in all regions as it was in the past. However, postharvest operations vary widely from region to region. The people initially obtained rice by hand pounding which is very laborious so they switched over to processing operations in "chakkis". However, when steel hullers were introduced, these two processing systems became totally outdated. In some of the hilly areas these systems are still used, although the quantity processed is negligible when compared with the total production.

Of the roughly 80,000 machines in India, about 72,000 are steel hullers. However, it has been found that modern rice mills are capable of yielding a greater quantity of marketable rice than steel hullers and under-runner disc shellers. Of the traditional mills, about 1,500 have converted to rubber roll

shellers and have modernized their milling section. There are still more than 5,000 mills left to be modernized. It would appear that the remaining 70,000 units are not economically suited to that style of modernization.

The proliferation of huller mills (for example, in West Bengal twenty years ago there were 6,000, but today there are 24,000) is largely a result of government policy. Most of the so-called village huller mills are not custom millers but really are commercial mills in disguise. This comes about because the organized or licensed rice mill must sell at a low price to the government an amount (levy) of 50% or more whereas the village miller has no levy requirement; therefore, his competitive position is highly favorable in times of shortage when rice prices are high. In earlier years, the 6,000 huller mills handled all the village requirements so it is evident that the additional 38,000 are really in the commercial field. It is very difficult to modernize the village mills under the present system.

Legislation has been introduced to force the steel huller mills to improve their operation, but so far no dent has been made in the number, in fact, the number probably has increased. Legislative measures for the replacement of the huller with other equipment could not be implemented because: (1) the huller is cheap, easily erected, operated, reparied and maintained even under village conditions; (2) it is available in small sizes and can also operate intermittently and hence is well suited for operating with small loss of paddy, raw or parboiled, as required by the consumers in villages for domestic use; and (3) it is capable of yielding polished rice acceptable to the consumers.

A number of solutions have been advanced to improve the villager's milling efficiency, but almost every one increased costs and did less overall. Some are acceptable only on one kind of paddy, some do not fulfill the basic requirement of the village mill. One of the reasons most often quoted for changing is that the offal from the huller is wasted and what is needed to recover it is a new type sheller with the steel huller used for whitening. The only thing that is forgotten is that to obtain salable bran what is also needed is a precleaner and bran separator and a bran stabilizer unit to hold the bran to accumulate enough from the neighborhood to hand it to the extraction plant. Now both capital and operating costs are increased. Otherwise, the farmer would have taken the huller bran home to his chickens or cow and would have recovered more net nutritional value.

The suitability of an alternative system is a factor of many inputs and in each specific case has to be adapted very carefully. The mini-mill concept is popular in India, and there are several types being developed and produced by Indian manufacturers. The ultimate will be decided in the market place. All of the tests, demonstrations and calculations are very true for a mill of adequate size to afford the investment necessary. The problem is that the "modern mill" proponents extrapolate calculations downward to the village mill thinking that the validity follows. This is not true. The only way to improve the overall conditions is to rearrange the social structure so that the number of single huller mills reaches its realistic level. That is, that they only prosper in the localities where there is no substitute. The larger

units could be modernized properly and healthily. One of the requirements to accomplish this on a long-term basis would be to equalize the levy so that all millers competed on an equal basis.

If there is adequate throughput, there is no doubt that a multi-stage configuration is economical. The additional income of the added rice recovery (to 67% from 63%) more than offsets the cost and loss of the mixed feed, or as done in the United States, the hulls and bran can be mixed back together and used as rice mill by-product feedstock.

Of the combinations available for village level improvement, the one using the centrifugal sheller (and any polisher) must be looked at carefully because of the centrifugal's reported advantages. (see detail, p. 78)

1. Deals better with high moisture paddy.
2. Deals better with mixed varieties (farm workers get paid in rice from many fields, and seed sometimes not pure variety)
3. Deals better with dirty paddy.
4. Has lower operating cost.
5. Has lower power comsumption.
6. Has lower capital cost.

And its disadvantages:

1. Not constructed too well. Down time is excessive.
2. As long as rubber ring is less than 70% worn, the hulling efficiency is 80%. When the ring wears, the efficiency goes to 30%, and this is the way they are run over half the time.

Several of the newly developed mini-mill systems use different configurations of the centrifugal layout. The need for an accompanying paddy separator varies with the whitening type and whether it is a parboiling situation.

A parallel is sometimes drawn between India and Indonesia and the introduction into Indonesia of the Japanese style mini-mill. The first difference, of course, is the complete lack of parboiling in Indonesia. It is said that the Japanese whiteners do not work on parboiled rice, though the authors are skeptical on this point.

Unusual configurations of dehusking machinery and polishing machinery were noted at Annamalai and at Kharagpur. Additional interest was shown in the Thai developed abrasive mill "Apollo".

A number of rice mills were visited in India. Configuration was normal but dependent upon the style of the mill. One common situation noted was the deplorable condition of most of the equipment and installations. A "breakdown-then-maintenance" approach was evident in almost every case, for example, operating the rubber roll huskers with the rolls almost completely worn out and so badly out of parallel that a finger could be put in between them on the front side while they would be together at the back. The side shields were often missing, the spreader plates being worn through with a hole perhaps 1-1/4" wide. In almost every case, the sheaths were worn unevenly with no evidence of interchanging rolls. It is difficult to see how these

machines can operate to any degree of efficiency. The steel hullers usually had one or both bearings out, the shaft bearing surfaces ruined, the cases with holes worn in them, the screens with holes in them. It would be interesting to see milling tests run on this production equipment as found in the actual average circumstance.

Thus, "modernization" of mills in India is focused at three different levels: (1) The commercial mill which is usually successfully modernized because the necessary economic factors are present to support substantial growth. (2) The village mill which is commercial (buys and sells rice) but consists of a single huller mill and must "modernize" by law as described below. (3) The single huller custom mill which is exempt from the levy (percentage sold to government at a fixed low price) and so far has also escaped "modernization".

CFTRI (and others) have been trying to improve the huller, or to improve results with a minimum of added equipment. Huller improvement has never been really successful (there is very limited potential for improvement in one-pass milling) so efforts have been focused on adding a sheller and one multipurpose separator. This is called the mini-mill because the purpose is to fit the situation now occupied by the single huller without further expansion. Although efforts have not been successful for the nontechnological reasons given above, the machinery developement is realistic and deserves watching.

Modernization got a push from a study comparing large modern commercial and village commercial mills (Number 1 below). Compulsory minimum standards for modernization were imposed by law on village commercial mills (No. 2 below). The development of the mini-mill has contributed to modernization in the sense of expansion, but also is expected to become a direct substitute for the single huller. The centrifugal sheller (3) and rubberized disc polisher (4) are considered most promising in this regard by CFTRI.

Outline of modernization of mills in India:

1. Comparisons of Modern vs. Traditional Mills. Seven different modern rice milling complexes from Europe and Japan were built to determine how they compared with the traditional Indian mills. They consisted of two sizes of Schule mills from West Germany, a GDR mill from the German Democratic Republic, a Kyowa mill from Japan and three sizes of Satake mills from Japan. All had rubber roll shellers and rice whiteners other than Engelberg hullers.

   Each of these modern complexes were compared in head yield and total yield against several traditional rice mills using a number of Indian varieties at the 4% bran removal level (undermilled rice). In each comparison, a single homogenous lot was divided and used in both the modern and traditional complexes. The different modern complexes were not compared against each other. In the areas where parboiling was practical, the same comparisons were made using parboiled rice.

   Traditional mills included two types of conventional mill systems which they defined as "sheller mills" and "huller mills". Sheller mills consisted of an underrunner disc huller followed by and Engelberg-type huller. Huller mills consisted only of Engelberg-type hullers, pre-

sumably in series so that the first dehusked and the second did the polishing (probably the same huller used twice). Whether single pass huller mills were included in the sutdy is uncertain.

For paddy, the average increases in total rice of the modern mills over the two traditional mills averaged 2.5% over sheller type units and 6.6% over huller units. For parboiled paddy, the corresponding figures were 0.8% and 1.6%. Increases in head yield for paddy, in the same order, were 6.1% and 15.1% and for parboiled paddy were 1.3% and 4.1%, respectively. Effects of the degree of automation and relative ages of equipment were not compared.

2. Modernization of Rice Mills. The new India Licensing Rules has made modernization compulsary under the law. In October 1977, of the 10,000 sheller cum huller rice mills operating in India, only about 1600 units have so far modernized by installing rubber roll shellers, paddy cleaners, and paddy separators. The government has developed three schemes for three types of plants: (a) Scheme I, Modernization of existing shellers for 1 ton per hr mills, (b) Scheme II, Same for 1/2 ton per hr mills, and (c) Scheme III, Installation of Parboiling and Mechanical Drying Plant in Modern Rice Mills. Capital costs of equipment, Additional operating costs, and Extra revenue attained were estimated as follows:

	Equipment costs	Per Ton of Paddy Operating Costs	Increased Value Per Ton
Scheme I*	Rs 150,000 ($19,000)	Rs 4.50 ($ .67)	Rs 37.25 (US 4.75)
Scheme II*	Rs 30,000 ($ 3,800)	Rs 13.50 ($1.72)	Rs 68.50 (US 8.85)
Scheme III	Rs 500,000 ($64,000)	Rs 8.50 ($1.13)	Rs 68.50 (US 8.85)

* Schemes I and II include costs of bran stabilizers.

(i) Cleaner cum Separator. A single huller rice mill can attain classification as a modern unit without addition of a rubber roll huller, if the centrifugal sheller and cleaner cum separator is added. The cleaner cum separator, low in cost and fed manually, is used to remove impurities from paddy and also to separate hulls from shelled paddy by means of oscillating screens actuated by an eccentric drive. Description of the unit, sequence of operations, and advantages are given below. For an investment of Rs 3,000 ($380), the return for a plant processing 200 tons annually would be Rs 3,000 ($380)--thus paying for itself in one year. The unit is used with the existing huller for polishing the brown rice. It is expected that a centrifugal sheller will be used in this operation for rural environments.

(ii) Cleaner cum Paddy Separator. Impurities in paddy such as iron nails, stone, straw, sand and mud particles, etc. have to be removed. For this, a simple oscillating sieve type mechanism has been developed. Screens of appropriate size are kept inclined in a boxlike device which is moved back and forth by an eccentric drive. Large sized foreign matter are screened out by the top sieve while paddy falls down and slides over the plate below.

This same unit can also be used as a paddy separator through insertion of suitable types of screens. The oscillating motion of the inclined screen causes a fair amount of separation in the first pass itself. Using appropriate screens for different varieties and adopting batch operation, satisfactory paddy separation can be achieved. The idea is to use the same unit first as a paddy cleaner and then after dehusking and husk aspiration, as a paddy separator. Below the inlet hopper of this unit are arranged certain wooden baffles through which the mixture of paddy, dehusked rice and husk flow down. A blower fan mounted at one end of the unit sucks out the light husk, leaving the paddy and rice mixture to fall on the oscillating sieve. Feeding these units can be done manually.

Sequence of Operation

1. Paddy is fed to the cleaner manually. While the blower sucks out dust and light particles, the oscillating screen removes foreign matter.

2. Cleaned paddy is fed to the centrifugal dehusker. Brown rice, paddy and husk are collected from this.

3. The mixture of brown rice, paddy and husk is then fed to the cleaner cum separator, manually. Husk is blown off. By the use of appropriate screens, unhusked paddy is separated from brown rice. A small percentage of paddy remaining in the rice stream helps in the polishing stage when the brown rice goes to the steel huller for securing the desired degree of polish.

   Use is made of the existing steel huller for polishing the brown rice. In this way, we make use of existing equipment such as huller and motor and improve the operation with minimum additional components.

Cost of Modernization

1.	Adding cleaner with separator, blower, and minor parts.	Rs 1,000.00
2.	Adding Centrifugal sheller in suitable frame, with feed hopper and pulley.	2,000.00
3.	1 HP motor with pulley, belt connection, and parts for driving the centrifugal dehusker.	1,000.00
4.	Incidentals, foundations, pulley and belt connection from huller shaft to "Cleaner-Separator" assembly.	1,000.00
	Total	5,000.00 ($630)

Note: Separate motor drive may also be given to the Cleaner-Separator assembly, 5 HP drive will be quite adequate.

Advantages

The huller mill modernized in this manner would help in saving up to 6% while processing raw paddy or up to 1-1/2% while processing parboiled paddy. Assuming that 500 tons are processed in a year per unit, the saving of raw rice works out to 30 tons and of parboiled rice to 7.5 tons/mill/year.

Value of raw rice saved	Rs 45,000.00
Value of parboiled rice saved	11,250.00

Even if we assume a mere 1% saving and consider 200 tons as the annual throughput, the return in the first year itself would be Rs 3,000 for an investment of Rs 5,000; this is quite rewarding.

Custom milling units can charge a slightly higher fee from the clients as the output is superior both in quantity and quality.

Bran from the modernized mill is richer in oil and should fetch a higher price. When a large number of hullers are modernized, it would be possible to collect the bran for solvent extraction of oil.

Modernization of the old huller type rice mills is therefore beneficial in many ways and goes to strengthen the economy of villages through low cost industrialization. Labor utilization for feeding the dehusker and cleaner is also a desirable feature of this huller modernization program.

3. The Centrifugal Dehusker. (From the promotional literature) This machine is a simple device consisting of two fast rotating parallel rings kept side by side, with a small gap in between. Paddy is fed through the center and is guided through metallic vanes positioned between the parallel plates. The flowing mass of paddy strikes a stationery rubber ring attached to the outer ring of the dehusker. The resulting action peals off the husk, leaving the kernel undamaged. A good percentage of the grain is dehusked in this way during the first pass itself. The dehusking drum measures about 35 cm in diameter and 16 cm in width. The rubber ring is only about 4 cm wide and is shaped suitably so as to install in the appropriate position in relation to the rotating impeller.

The rubber ring wears out due to abrasion and is to be replaced after reportedly shelling about 20 tons of raw paddy or about 30 tons of parboiled paddy. This operation is, however, quite simple and can be easily and quickly done by the mechanic. These rubber rings are also readily available from the suppliers. The rotating parallel plates and the guide vanes are made of hard metal to withstand the abrasive action. Different manufacturers in India who have started producing this line of equipment stipulate varying levels of guaranteed life for the impeller plates, and it should be possible to continue this improvement still further.

The equipment size in common use is capable of dehusking paddy at the rate of about 400 kgs/hr. and can handle small lots. Therefore, it can do the job for which the single huller was hithertofore being employed. A 1 HP motor drive is sufficient to power the unit. The dehusker mounted on simple framework is connected through a pulley and V-belts to the electric motor to provide an RPM of around 3500.

Output from the centrifugal dehusker is comparable to that from a modern rubber roll sheller. Elimination of rice breakage and prevention of admixture of husk with bran are the twin benefits of this device. (Note: the authors feel that the actual outcome depends on many factors and conditions during operation.)

This unit, along with a cleaner cum paddy separator, is used to modernize single huller rice mills. By using these two pieces of equipment, a single huller rice unit will be classified as a modern unit under the Rice Milling Act and Rules which makes modernization compulsory. Cost of centrifugal dehusker is advertised at Rs 2,000 (US $257) for the dehusker and Rs 1,000 (US $127.50) for a 1 HP motor and belt connections. Van Ruiten in the publication "Rice Post Harvest Technology" (20) states that the small centrifugal huller is still in the development stage.

4. <u>The Disc Polisher</u>. The centrifugal sheller is expected to be used with the existing huller used as a polisher. However, for mills purchasing sheller and polisher, a disc polisher consisting of the top disc of rubber and the bottom of emery-coated steel is recommended by CFTRI because they say a smaller size is available than with cone design.

Milling By-Products

<u>Rice Bran</u>. Rice bran in India is utilized in two fashions depending on the milling system from which it is derived. Single stage steel huller mills produce one product, huller bran, which is utilized as a feed for animals and poultry. In multi-stage mills, the separated bran can be collected and extracted in a solvent oil extraction plant, if the economics and logistics are favorable. This is done to considerable amount in India.

<u>Rice Bran Oil Extraction</u>. The oil extraction industry in India is somewhat sophisticated. A number of different systems are used throughout the country on a number of different raw materials, one of which is rice bran. Most of the problems or criticism of India's oil extraction plants really are logistical problems, not ones of the technical side. The extraction of parboiled rice bran is apparently a very worthwhile business, if the conditions are right. Recoverable oil from parboiled bran is 22-28%, depending on the method of parboiling, compared to 16-18% from raw rice bran. This is with a 4-6% polish of the brown rice.

The several oil plants visited were in full production and a number of the rice mills reported their shipping of bran to these oil plants. In 1975 and 1976, the production of rice oil was about 77,000 tons as compared to only 5,000 tons ten years earlier. India is second to Japan as the world producer of rice bran oil. It can be expected that this production will increase each

year as more mills become capable of suitable bran production and the demand for the finished oil continues. India is a deficit country for vegetable oils and can absorb all rice bran oil that could conceivably be extracted.

Bran Stabilization. There are a few commercially sized rice bran stabilizers in use in India. They are of the steam jacket heated type and used in large mills. No information is available on their individual performance or the superiority of that type over any other.

There seem to be no small scale stabilizers in use, though academically there is considerable interest in them. Development work is under way at CFTRI-Mysore, IIT Kharagpur, Annamalai University, PPRC, Tiruvarur, the Ministry of Food in New Delhi, and the Department of Food Technology, Jadavpur University.

The feasibility of bran stabilization in a large mill is without question. The real test is with the stabilization and collection system for the small mill and whether economically the recovery of oil can have a significant effect on the ability of the village mill to improve its systems.

Rice Husk. Current use of husk in India is confined to fuel and feed. A number of exotic uses are being investigated but there is no commercial utilization outside of the fuel and feed fields. Most of the husk produced in India is present as an ingredient of huller bran which is used for animal feed. In the multistage mills the separated husk is used as a fuel for boilers or heating vessels and in other applications as a direct fuel for mechanical driers.

Investigations include:

- Particle board and brick
- Cement from ash (Ashmoh, ITT-Kanpur)
- Extraction of silicate
- Silicon manufacture (IIT-Kharagpur)
- Stoves for village use.

THAILAND

General

	1973/74	1974/75	1975/76	1976/77	1977/78
Area - Th ha	7950	8232	8471	8600	8600
Yield - MT/ha	1.81	1.76	1.77	1.74	1.80
Production - ThMT	14,350	14,500	15,000	15,000	15,500
Milled - ThMT	9471	9570	9900		
Export - ThMT	1046	934	1300	2900	1500
Consumption - Kg/Cap	193	194	191		
Production - Kg/Cap	231	225	226		

Rice production in Thailand uses 62.5% of the arable land, and 70% of the population (37 million) are rice farmers or live on rice lands. Most paddy in Thailand is marketed through a middleman system. Because of the very heavy domestic consumption and the relatively small amount of export (10%), the existence of an export grading system was not mandated on a countrywide basis. The purchase of paddy from the farmer by the trader is not based on quality. Thus, no definitive incentive exists in Thailand for the farmer's improvement of paddy quality. This absence of quality assessment is partly derived from the technical difficulties inherent and partly from the absence of accepted standards and official grading methods. This situation puts each transaction on a negotiated basis which usually works to the farmer's disadvantage.

Losses

Figures for reported total losses of rice within the postharvest system are:

FAO (1977)

	Report 1	Report 2
Total losses	8-14%	12-25%
Farm storage	1.5-3.5%	2-15%
Central storage	1.5-3.5%	---
Handling	---	10%

Threshing

In the north and south of Thailand, a necessity in the threshing area is a huge, flat, round container made of bamboo sticks, known as a "kra dong". In the north, the paddy bundle to be threshed is placed securely between two pieces of wood that serve as a handle. The bundle is beaten against the "kra dong" so that the grains will come off the panicles; 4-6 persons can thresh about 2 tons per day. In the south, the branched paddy cut with a knife is too short to be threshed this way. Therefore, the southern farmers place the bunches of paddy in the "kra dong" and thresh them with their feet. In the northeast a small farmer does his threshing by beating the rice stalk against a wood board. As soon as the threshed grain forms a small pile he stops the beating and winnows the grain by fanning the pile with bamboo fans at the same time stirring the pile of grain. In the central plain and in the northeast, larger farmers thresh their paddy on the ground. A dry, hard, and smooth area is chosen for the purpose. It is cleaned and then coated with a mixture of

buffalo dung and mud, which cements the cracks in the ground and prevents the loss of paddy grains into these cracks. The paddy bundles are beaten against the ground. Some farmers let the buffaloes do the threshing by walking them over the paddy bundles. Small pickup trucks and tractors are used in a similar way. Another threshing method is with a two-wheel tractor trailing a free wheeling roller with fins. This type of threshing can result in greater loss of paddy grains because of grain cracking and dehusking. Therefore, manual threshing is still preferable to animal or mechanical threshing from a recovery standpoint. Wet season threshing of second cropping paddy is usually done inside the barn by using the hand (2 wheel) tractor to thresh the rice stalk in the same manner as done outside in the dry harvest period. Threshing cost for the wet crop is higher than for the traditional crop because the paddy at higher moisture content is harder to clean, therefore more labor is needed.

In the last two years, IRRI designed, Thai built, axial flow threshers have been introduced in the commercial areas of the central plain. The impact of these threshers and their progeny has yet to be felt but all indications are that it will be great. The prognosis for acceptance is good because, (1) the effort made by IRRI to aid manufacturers and to encourage introduction of these threshers is on a large enough scale, and over a long enough time period to insure success, (2) the Thai farmer of the central plains has a commercial philosophy, and (3) he has the cash flow to afford the use of one of these machines. This is usually not true elsewhere.

Other thresher designs are being developed, particularly in the very small size machines. At the Department of Agriculture, Agricultural Engineering Division, Bangken, a peg type on a powered drum is being fitted with a conveyor to separate paddy and straw.

Some varieties of rice when threshed in the axial flow thresher retain their beards on the paddy. The market adjusts for these varieties with a lower price. A debearder has been developed at Asian Institute of Technology (AIT) to cope with this problem.

The authors visited a thresher manufacturer at Chachengsao who was building IRRI designed axial flow machines and an entrepreneur (Chamnien Nantasorn) near Don Chedi (Suphan Buri) who used one for the first time in his custom threshing operation in December of 1977. By August he had sold 20 and had eight in use in his operation. The thresher cost $800 (1978).

At Kasetsart University some work has been done in evaluation of a Japanese pedal thresher. Field tests showed problems with awns similar to axial flow thresher outturn problems. Professor Lars Rubsiri was involved in this.

Cleaning of threshed paddy at the farm level is limited in Thailand. There are several methods used manually, all of which could be classed as some sort of winnowing utilizing the wind.

The beginning of mechanization is shown wherein a farmer handling larger amounts of paddy cleans with a locally made mechanical wind blower. The frame

is made of teak wood, the blade is made of plywood, and the rotor as well as the other important parts are made of cast iron. An entire unit costs about $30.

When the IRRI type axial flow thresher is used the grain is cleaned in the machine.

Drying

Drying requirements in Thailand are less critical than in some other Asian countries because the major crop is harvested at a relatively dry period except for unusual showers. The bulk of rice paddy is dried by sundrying.

AIT has several solar powered dryer projects underway. Dr. Exell has been using a grant from IRDC on development of a solar powered rice drier. Several driers are installed on local farms. There seemed to be no other formal activity regarding solar drying. Papers have been presented at both SEARCA workshops - Bangkok '78 and Jakarta '79.

In an interview with regional officers of the Don Chedi Cooperative, three officers present stated they had never seen a mechanical drier, though all believed that these could be of benefit, particularly for the wet season crop.

Mr. Bunyaphlanan and Mr. Tunpun of Kasetsart University stated there were no commercial driers in Thailand, any initiative must come from the Department of Agriculture. Professor Rabsiri at Kasetsart University has designed and tested a bamboo bin with drying aeration capability. This type of development seems to hold considerable promise, particularly in areas where storage is of value. His test of this bin-drier showed 6 ton capacity. 22 to 15 moisture percentage reduction in 10 hours was obtained using 2 gallons of fuel for driving the fan. This is a concentric tube type drier of 2.5 meter height and diameter with a stub tube 1.3 meter high.

Some of the commercial mills have column and LSU type driers to use on their parboiling operations when the sun drying yard is too wet and possibly on raw paddy intake during the wet season. Kamchai's mill has a complete drier complex with steam heat exchanger units from the husk fired boilers. He also has rotary type direct fired drier available and uses it to bring down 40% moisture parboiled paddy to 14% for milling. However, many of the smaller commercial mills do not have any artificial drying backup capability but depend on sun drying yards for both parboil intermediate drying and for for any raw paddy drying necessary. However, these mills have no formal way of determining moisture and sometimes get some high moisture paddy in their receiving lots.

Parboiling

Parboiling of rice in Thailand is described to be 1-4% of the crop which could reflect up to 40% of the export value. Except for specialty situations no parboiled rice is consumed in Thailand. The advantages to the miller exporting parboiled is evident. He has a regular clientele whereas on white export he has heavy competition; he can use the poor grades, therefore cheaper grades, of paddy. For instance, a paddy that would produce 50% brokens on

white milling will produce 20% brokens on parboiled milling; and he gets a higher price if his quality is good. Exports are to the traditional parboil markets: Indian people in many countries; Malaysia; Nigeria, South Africa and Saudi Arabia. Parboiling is done in various parts of the country but the market outlet is Bangkok.

Kamchai's mill has unique parboiling arrangements using steaming in dump trucks. T his is a most innovative concept and valid where the amount being processed is of large enough quantity. He is using hot water soaking with 100 tons in each soaking tank. His milling schedule comprises about 50% parboiled and 50% white.

Milling

Rice milling in Thailand can be thought of as being in four levels:

1. Household processing manually.

    a. Hand pounding or dekhi
    b. Thai clay mill

2. Village or custom huller.

    a. Steel huller-Engelberg type
    b. Abrasive stone roller (Apollo or Pin Kaeu)
    c. Mini mill

3. Domestic commercial

    a. Traditional but sometimes modernized
    b. Modern mill

4. Export commercial

    a. Traditional configuration with modern additions
    b. Modern mill

There are only small pockets of manual processing, concentrated in the south.

Village millers are responsible for the unusually large increase in the number of rice mills and milling capacity in Thailand. Even though great pressure has been brought to outlaw the steel huller and replace it with the abrasive roll, the fact remains that steel hullers are still made and sold. There is no data available on distribution and numbers of the various types of mills used in village level milling. Domestic commercial mills are usually classic Thai disc shellers with cone whitener mills, locally built, with steam powered from a husk fueled boiler. They include precleaners and grading sifters, and are almost always copies of turn of the century European equipment. Some now are adding a rubber roll sheller as a return sheller and some have replaced the disc primary sheller with a rubber roll. Usually these mills are 1-2-4 TPH configuration, are quite simple, and very sturdy. The export mills are usually larger and may contain greater amounts of grading equipment. The primary husker may or may not be in combination as in the domestic mill.

Since about 80% of the rice in Thailand is consumed locally the methods of milling are a factor of household practice.

The terms of hiring for milling for home consumption paddy have detrimental effects on the recovery of milled rice and indirectly, contribute to losses of edible rice. The miller who does not assume any responsibility for the quality of milled rice tends to overmill in order to obtain higher production of bran which he receives as part of the milling hire. There is not only physical loss as the result of overmilling but also loss of nutrients such as protein, fat, vitamins and minerals which are present in greater quantities in the outer layers than in the starchy endosperm of the rice kernels. Bran and small broken endosperm fragments, and part or all of the hulls would ordinarily be sold by the miller as animal feed.

In the Central Plain, some millers were running around with light trucks among the villagers offering the milling rate with free transportation. The usual rate offered was about 50 percent by volume, bran and brokens being collected as a milling fee. These mills are usually 2-5 MT/hr units.

In the northern areas the usual practice of the farmer was to bring about 30 kg of paddy at a time to the rice mill or rice milling unit and get back milled rice and rice bran (plus hulls). Three baht ($.15 U.S.) is charged as a milling fee.

In the Northeast, rice milling units found mostly were of Engelberg steel huller type, though domestic rice mills capacity of 2 tons per day were also found in larger districts. Ordinarily the farmer brought small amounts of paddy (about 30 kg) at a time to the miller, bran and brokens were collected by the miller as a milling fee.

Practically all the rice received in the exporters' warehouse needs to be regraded before export shipment. The need to regrade rice prior to shipment is to ensure that the content of the rice shipped is consistent with that of the quality contracted. The regrading of rice is done manually by removing the brokens using appropriate perforated sieves. This laborious practice of regrading of rice still adopted by the exporters indicates that the quality grade is a dominating factor in the export market of Thai rice. The inability of the majority of the rice mills to produce a uniform and predictable standard is another reason why regrading is necessary. This process is laborious and costly as it involves additional handling, rebagging and restacking, and incurs physical losses of edible rice.

An experimental project is underway to develop a viable mini-mill to use in village situations. With FAO assistance, U Maung Maung has built a 1-1/2 x 6" rubber roll sheller coupled with a Thai abrasive roll and a small separator. The roll is manufactured by Prapadong. The unit has been sent to Chan Buri for experimental work.

Whether any centrifugal huskers are used or not was impossible to determine. Conversation concerning their efficiency and adaption was encountered, but the authors did not see any. It was said that the Department of Agriculture had tried both horizontal and vertical configuration types three or four years ago, but results were unobtainable. Maung Maung said that centrifugals were

tried in Burma and Malaysia, and that he had seen one with an 18" impeller of plastic. He thinks that they break too much rice and wear out too quickly.

Projects

1. Under an IRRI-Thailand project at Bangken, Suwit Bunyawanichkul is working on introduction of mechanical threshers in Thailand, both developing manufacturing capabilities and extension efforts.

2. Dr. H.G.R. Reddy, and Y. Koga of ESCAP are interested in backing "the Laguna team" in identification and implementation of post harvest projects in Thailand, Malaysia, Indonesia and Phillipines.

3. The Department of Agriculture "Klong project" is developing village level drying capability, including storage-dryer-structure and equipment.

4. An AID-IRRI-study of consequences of small rice farm mechanization on production, income and employment, akin to the Philippine "Bicol" study is underway.

5. The AID mission in Bangkok (Cooper) stated:

   a. Thai government has not requested any projects concerning rice post-harvest technology.

   b. AID efforts are not aimed at infrastructure.

   c. Any activities must impact on farmer, particularly in the North and Northeast.

   d. Projects are specifically aimed at provinces named - three or four in a project.

   e. As of FY77 all AID projects were being phased out and rescinded at request of Thai government.

6. FAO Regional Office. Activities of the FAO Regional Office include programs for all of the Far East. Particularly of interest at this time are the Small Farmer Development Project under de los Reyes. This encompasses 8 countries, including Thailand.

7. IDRC supported work at the Department of Agriculture, Bangken, on milling and drying activities includes development of: (1) alternative fuel systems designs on prototype farm dryers; and (2) the development, testing and introduction of "small rice milling unit." (Thai abrasive roll)

8. AIT (Jindal) has submitted a project proposal to the John F. Kennedy Foundation on rice drying using unheated air or supplemental heated air. The drying effect upon subsequent milling behavior is included.

9. AIT (Singh) is evaluating the Apollo mill at IRRI request.

SOUTH AMERICA

General Discussion

In South America rice tends to be mainly a commercial crop, the subsistence crops being the more traditional native crops of a particular region. Thus, rice is thought of as essentially for sale, even though some farms are quite small and in some locations processing is done by hand. Because of this commercial mentality in the rice producers and processors, infrastructure development is critical to the success of rice operations. The rice processing technology of South America is basically early European with some Asian influence especially west of the Andes and in Central America. There is a great desire for technical information among rice workers at all levels in South America and a surprising lack of availability of it to them.

COLOMBIA

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	291	355	372	325	379
Yield - MT/ha	4.04	4.34	4.34	3.99	4.30
Production - ThMT	1,175	1,540	1,614	1,297	1,631
Milled - ThMT	764	1,001	1,049		
Imports - ThMT	---	---	---		

In Colombia the large rich farm lands which once produced rice now produce sugar cane and other high cash crops. Rice is now produced on less favorable lands which require more complex irrigation, transportation and processing facilities. However, the general infrastructure here is well developed and the Colombians have been overcoming potentially adverse conditions to the point of supplying their own rice markets at a distance from production, exporting rice, manufacturing processing equipment, and even doing some research. Fedearroz and Instituto de Investigaciones Technologicas (IIT) plan a thorough scientific survey of post harvest losses in rice in Colombia in 1979-1980. Previous overall loss estimates for rice have ranged from 1 to 8% of total paddy (Table 1). Their rationale for the more detailed study is shown in Table II and the discussion following it. Their preliminary information indicates drying and storage to be the postharvest problem areas causing most of what losses there are in Colombia. The increase in rice production due to both higher yields and increased acreage are partially to blame. Any recent changes in rice processing operations which may have occurred in the small percentage of Colombian operations based on flood land production, or dry land farming, were not identified.

Threshing

Combines are used wherever the terrain allows. There is a small percentage of rice harvested and threshed without machines. Perhaps the planned loss survey will reveal a potential for smaller scale machinery in this sector.

Drying

Fedearroz estimates that perhaps 60% of Colombian rice is mechanically dried in medium sized silos, 20% in sack tunnels, and the rest either in conventional columnar driers or sun dried. Drying in sack tunnels is an innovative attempt to dry mechanically while reducing both capital and handling costs. Sacks of rice are piled to form tunnels closed at one end, with sides and top of equal thicknesses. Air is blown into the open end forcing it to pass through the rice in the sacks. Even with loose rice filling the spaces between sacks, drying is not uniform and losses in quality and sometimes in rice have resulted. Part of the problem is nonuniformity of moisture within sacks due to moisture pickup through the bottom of sacks in contact with the damp ground out in the fields. Drying in silos is drying in bins of 1-1/2 meters depth of rice using ambient air if below 65% R.H., or heated air if above 65% RH, starting within 24 hours after harvest with rice at 22% moisture and reducing to 13% by drying during daylight hours over about four days. This drying

works well except that overdrying often occurs due to lack of controls and overdried rice breaks up more during later milling causing increased losses. The same electric fan and oil heater unit is used for the silos as for the sack tunnels. A unit which delivers about 58,000 ft^3/min costs 310,000 pesos ($8600) and in the case of silos each holding 2400 kg rice. These portable blowers are produced by SB Industrial and Commercial Ltd. (SBIC) Bogota. Another major drier producer is Empresa Metalurgica Colombiana (EMC) whose drier is the U. S. "Aeroglide" drier. Driers are also made by the mill manufacturers; for example, El Condor in Tulua makes a columnar drier.

Parboiling

There is no present demand for parboiled rice in Colombia, or for that matter in most of South America. Yet Colombia is attempting to begin parboiling rice with two centers now in production, one 7000 ton/year plant in Duitama 200 km N.E. of Bogota belonging to Union Molinera, S. A., and a larger 80,000 ton/year plant in Villanvicencio 130 km S. E. of Bogota belonging to Soceagro. These are large commercial ventures which must overcome transportation and quality costs and make a profit in a world market in order to succeed. The companies have a dometic marketing promotional campaign which might catch on, and there are tax incentives for exporting. The machinery is very modern, from Taiwan, West Germany and the U. S. including an electronic rice classifier. Smaller operators all over the country are watching these developments with great interest.

Milling

The smallest mills observed in Colombia were domestic commercial ones of about 1/2 ton/hour capacity consisting of separate pieces of equipment for each step, rubber roll shellers, under runner repass, cone polishers and all the associated paddy separators, cleaners, and graders including a bin to feed the rubber rollers, but no de-stoners. All the types of milling equipment are made in Colombia except the rubber rolls and friction pearlers (jet-pearlers) which are of Japanese design made in Taiwan. The Colombian made pieces are standard classical European designs and the same types can also be obtained by importation. The mills are usually well run and the miller tends to upgrade his equipment because the more modern mills are more profitable. There is grading for brokens and for quality (about 30% of production is sold as Excelcior, 5% brokens). The husk is not utilized but bran goes to animal or small amount to oil extraction (1 plant).

Other

Manufacturers in Colombia are able to make equipment from designs, add innovations, do very limited testing, and to export to neighboring countries.

CIAT (Cali), which provides seeds to a network of nurseries in some other Latin American countries, is interested in the postharvest area but has no facilities or personnel currently assigned to this area, and thus probably would require years to develop as a post harvest center.

The study of losses which is planned by I.I.T. and Fedearroz include marketing and storage, and should provide useful experience as well as data. Although

the major goal is to identify and reduce losses in the total large rice volume, it may clarify information regarding very small producers, and it could serve as a model for studies in other Latin American countries. I.I.T. has already completed a loss study of yucca and plantain.

Table I. Loss Values for Rice and Beans in Colombia Obtained by Several Separate Studies

Study		Rice Loss (%)	Beans Loss (%)
OPSA (Dept. of Agr.)	1973	1.0	10-11
ICBF (Welfare Inst.)	1972	3.0	3.8
Weitz-Hettelstater (Private)	1965	6.0	---
DNP (Govt. Planning Dept.)	1976	8.2	7.6
Averages (used in Table II)		4.55	7.3

Table II. Postharvest Loss Data for Rice and Beans in Colombia

	Rice	Beans
Production ThMT[1]	1,837.4	65.7
Losses (%)[2]	4.55	7.3
Volume of Losses, ThMT[3]	83.6	4.8
Price of Product, Pesos/Ton[4]	8,000.0	34,300.0
Value of Losses, Million Pesos/Year[5]	668.8	164.6

1 Source: Minagricultura "Agricultural Programs 1974-1975". 1976 data estimated.

2 Averages of the results of several actual studies. The individual values are given above (Table I).

3 Production times percentage loss.

4 Source: IDEMA, Purchasing Division, May 1976.

5 At 36 pesos per US Dollar, value of losses in US dollars: Rice, 18.5 million; Beans, 4.6 million. A reduction of one percent for rice would be a savings of 4 million US dollars.

The large production volume of rice causes the volume and value of the rice loss to be quite large, larger than that for beans, for example, even though the percentage loss and the price per ton is greater for beans (Table I). If the percentage loss for rice is underestimated, as the most recent estimate indicates (Table II), the total amount of loss is even greater. Fedearroz and IIT believe that they cannot afford to ignore such large amounts.

BOLIVIA

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	41	45	45	63	54
Yield - MT/ha	1.66	1.67	1.67	1.59	1.57
Production - ThMT	68	75	75	100	85
Milled - ThMT	48	53	53		
Imports - ThMT	---	---	---		

Rice is a domestic commercial operation in Bolivia with only an estimated 2% considered subsistence and that only because of lack of transport. Rice takes up only 10% of the total cultivated land, being located both in pockets in the Andes (15%) and on the eastern lowlands near Santa Cruz (85%). The Santa Cruz area seems to have the potential for greatly increased production, though limited, as yet, by marketing considerations. Recent attempts to take advantage of this potential have aggravated some already questionable practices in rice handling. For example, the rice crop of a small farmer, is often purchased for cash by a traveling broker who leaves it stacked in the field bringing small amounts to the miller at intervals during the year. This practice alleviates the momentary oversupply at harvest but invites losses of various types. When rains occur at harvest the farmer is unable to use the roads and the rice remains in the field no matter who owns it. When the roads are passable, moving the large quantity of rice at once has still posed a great problem for the farmer. Increases in production add to the difficulty.

In very recent years, the government of Bolivia has succeeded in increasing rice production in the area by increasing the available loans for rice from the agricultural bank (Banco Agricola de Bolivia). The local system which is based on moderately small farms and mills has not been able to handle large surges in production. The government, together with the various rice related organizations, have been attempting to collect the rice, dry it, store it, and market it properly but have not yet succeeded. The difficulties have inspired several studies and action plans, aimed at improving the infrastructure and technology for rice in the area. The goal is for the government rice buying agency to purchase the excess production, storing it in silos in Buena Vista (north of Santa Cruz), and shipping it out to sell. In 1977-1978, neither the Buena Vista drying facility nor the marketing channel itself was able to handle the especially large quantity of rice at harvest, resulting in spoilage on the one hand, and a price drop on the other. Of course, adjustments are planned. Among those discussed are a more gradual increase in credit availability, with a closer coordination between production and market, scheduling of harvest and delivery to the Buena Vista facility to allow time for proper drying and even establishment of many smaller facilities out in the growing and harvest areas where rice would be purchased, dried and temporarily stored.

Threshing

In the Santa Cruz area, the predominant rice group area, 70% of the farms raising rice are less than 5 hectares, an additional 29% between 5 and 20, and

1% over 20 hectares (Dept. of Statistics, MACA, August 1978, La Paz). Harvest is said to be about 25% by machine, 75% by hand (local Japanese and Menonite groups tend to use machines). Hand harvest leaves much of the straw uncut.

About 5% of the rice is threshed at the mills, usually on several small threshers made in Argentina, the rest in the field where both machine and hand threshing are extensively used. Threshers observed in the mills were similar to the ones used in fields in Taiwan, or the IRRI thresher with loops, and similar ones would be available for field use. No doubt larger ones are also available to those who can afford them. All rice processing machinery is imported; the designs are usually European but made in Brazil or Argentina. When threshed in the field, the rice is transferred to the mills in bulk.

Drying

The harvested unthreshed rice may be dried in piles in the field, (sometimes on a floor of logs), transported a longer distance to the government purchasing facility at Buena Vista, or taken to a private mill nearby. The difficulty in transportation and the low price at harvest tend to encourage field drying. The farmer may sell at a low price to a traveling broker who can take the rice to the government facility where he obtains the higher "minimum" price, or to a private mill. After purchasing, the broker may also leave the rice to field dry, selling later at the higher season price. The miller is often careful to avoid using a moisture meter when buying, since such use is associated in the minds of the farmers with "discounts" and might inspire the farmer to sell to some other miller. Instead, he negotiates a price based on the overall condition and the knowledge that the farmer has limited places to sell. The miller then dries the rice by sun in his drying yard, if possible, and by using commercial driers when the rice volume or weather requires. He often uses a moisture meter in his internal operations. The driers are moderately large commercial ones of various styles, including recirculating thin bed types and even a rotary kiln. Since wood is plentiful, it is used for fuel, as is diesel oil. One mill had three machines, one wood, two diesel, with a capacity of 35 cwt per hour. The routine was to dry the rice from 28-30% down to 14% in 10 hours, then put it in wooden bins having screen bottoms. The stored rice was aerated and fumigated every 15 days until milled. The miller mentioned the lack of available information on rice processing technology in Spanish.

Theoretically, the large government installation at Buena Vista (ENA) would be able to buy any farmer's rice at harvest, allowing him a better price, and dry it properly and store it, allowing better quality rice. So far, the farmer has experienced difficulty moving the rice to the one facility and even so, the rice which has arrived has sometimes been too much for the driers to handle. Also, the practice of selling to the mills by the government has caused marketing problems.

Parboiling

There is no parboiling in Bolivia.

Milling

The mills are usually small to medium domestic commerical ones with all parts imported from Brazil or Argentina where they are made, usually following older European designs. The rubber rolled shellers are Asian style made in Brazil. Some mills do milling for a fee (e.g. 17 pesos/cwt) but whether toll (village) milling is common is not certain. It appears most of the crop is sold to the miller. Again the lack of thorough technical knowledge results in adequate equipment run reasonably well but not to the best advantage.

Other

Practices and incentives probably contribute more to losses than does lack of machinery. The amount of loss from practices such as field drying and storage depend greatly on chance. There have been studies, including some sampling, to provide recommendations for changes in the system, but the reports reviewed so far have not included quantitative loss data.

There is no center for post harvest research. There is an extension service, but it is said not to function. There are cooperatives for the farmers and a "federation" of the coops (FENCA) which has hired a consultant to help improve management and identify problems. There are a great many middlemen in the marketing chain so that the cost at market is sometimes higher than the market price and the price at the farm lower than the cost. There is a rice production research center (CIAT - Bolivia) which raises seeds obtained from CIAT - Colombia for local farmers. But pure varieties are the exception, since no premium is given over mixed varieties anywhere in the market chain. In fact, rice of good and bad quality are mixed in the drying yard, if not before. Financing seems not to have been a problem recently due to activities of the government and donating agencies.

Machinery could help especially with the smaller producers but just where and how will depend on how the rice system evolves in the next few years. The area probably would be ideal for a more thorough, sound, scientific study of losses because activities are so concentrated. Perhaps CIAT could serve as a central source of postharvest information.

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	4,463	5,250	6,000	5,200	5,400
Yield - MT/ha	1.44	1.33	1.42	1.44	1.56
Production - ThMT	6,421	7,000	8,500	7,491	8,400
Milled - ThMT	4,366	4,760	5,780		
Imports - ThMT	20	40	---		

There are three basic styles of rice production in Brazil. In the state of Rio Grande do Sul (southernmost area) rice is the major crop. It is produced by irrigation and modern methods, supported by production research, processed and marketed with reasonable efficiency, both as white and as parboiled, and part is exported either to northern Brazil or overseas (Africa). In central Brazil, rice is used as the first crop after new lands are cleared, since it tends to stabilize the cleared soil. This upland (nonirrigated) rice depends on natural rainfall which varies widely from year to year, causing the production volume also to vary. In wet years, the area is self-sufficient. In bad years rice must be imported from the South. The production is mechanized, supported by production research, and successfully marketed. In the northern areas, rice is produced on floodland ("wet lowland") or land which does not flood but whose soil tends to hold water well ("dry lowland"). Although the soil in the North is less troublesome than that of the central regions, the general infrastructure, production, marketing, and so forth, is much less advanced than either the central or southern region. Self-sufficiency rather than export is the government's goal for this region, partly due to the lack of ready markets, partly due to the sometimes poor quality of the rice. Although mechanization exists, subsistence and village level operations hold equal place with the domestic commercial. There are several pilot projects in parts of this vast northern area, some supported by foreign governments, which aim to raise the economic level of the local people by increasing their effectiveness in production and processing of rice. Since Brazil is so large, the state governments as well as the federal are active in agriculture. EMBRAPA, a federal agency, supports regional research programs of the State and University centers with money and coordination, as well as carrying out a limited program of its own. Extension is not only active in Brazil but has a large voice in determining what research is done with a result that most agricultural research in Brazil is applied rather than basic, and practically all is production oriented.

Threshing

Combines are used in much of the South, all of the Central and part of the North. When the price of rice is high, the number of small farms producing rice increases. They rent combines at harvest. In the North, however, hand harvesting and threshing is quite common. The amount of hand harvest but machine threshed is unknown but some machine threshing is also done there using small IRRI type threshers. In the North, rice is transported in bags; in the South bags are also used but bulk transport is becoming more common.

Drying

Drying in the South and Central areas is largely mechanical but not always. In fact, sometimes the rice is already dried before harvest. When harvested at higher moistures, rapid mechnical drying is common. If rains occur at harvest, the producer waits with the result that quality may suffer but losses to outright spoilage are rare. In some rudimentary areas in the North, field drying is more common but mechanical drying exists also. It is said that lack of information on proper methods is a recognized cause of losses. Driers are manufactured in Brazil as are other types of rice processing equipment. Kepler Weber (Mathews) is a large company specializing in driers.

Parboiling

There are said to be at least three places where parboiling is done in Brazil including Rio Grande do Sul, and Goias. Parboiled rice and Arroz Macerado, which is somewhat different, enjoy some tax preferences not given to white rice and are increasing rapidly in popularity with Brazilians. Probably the amount of parboiled production will increase. These are export level operations.

Milling

Mills in Brazil are usually medium size "packages" based on older European technology (one to three tons per hour). Two manufacturers of these mills in Brazil are Luccato and D'Andrea both located near Sao Paulo. It is possible the very small Engelberg style mill so common elsewhere is not made here; however, there is one similar to the Sataki "family mill".

Noguera and others were said to be made in Brazil having a capacity of 12 bags a day and costing about 25,000 Cruzeiros. Rubber rolls are made in Brazil which are less expensive but do not last as long as imported (Sataki). Of course, some very large export mills exist, and even small laboratory mills are made here for test milling consisting of a rubber roll sheller and screen whitener in a single unit (Suzuki).

Other

Brazil has the ability to manufacture but has not incorporated much new technology into their rice equipment. The majority of the rice producing regions are advanced, and additional postharvest information would be used to refine an already successful system. In the North, however, the system is much more rudimentary and would benefit from small scale technology. Postharvest research (and extension) could be started easily in Brazil, since the facilities and some personnel already exist, but the new programs would compete and take away from the present ones (e.g. production). Some nutrition studies are being expanded to include postharvest losses but this is still in the discussion stage. The SIBAN foundation has included postharvest losses as part of its Food and Nutrition Symposium in Porto Alegre in 1981. Also, there was planned to have been finished by early 1979 an assessment of all milling machinery in Brazil (no details available).

General Discussion

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	110	115	117	125	105
Yield - MT/ha	4.10	3.70	3.90	4.44	3.81
Production - ThMT	451	426	456	555	400
Milled - ThMT	302	285	306		
Imports - ThMT	---	---	78		

About half a million metric tons of rice is grown each year in Peru in three major areas: (1) the north coast (ca 75%), which harvests from May through August; (2) the southern (Arequipa) area (ca 10%), which harvests from from February through April; and (3) the jungle areas (ca 10%) which harvests from November thorugh January. Since the mills operate beyond harvest time, there is rice processing somewhere in Peru virtually all year round. Since the coastal areas are desert, the rice there is grown in about 50 river valleys using irrigation water from the rivers which depend, in turn, on the yearly rainfall. The southern area is also irrigated, but the jungle is directly rain fed.

Rice has been grown for many generations in Peru and is the staple food for a substantial part of the population. Due to drought and other factors, production dropped to 365,000 MT in 1978 causing widespread hardship and actual starvation in some areas. Unfortunately, the national debt of Peru was already very high so that importation of the necessary rice to make up the deficit was also a hardship. Peru has just finished a land reform, transferring some large estates into the hands of smaller farmers and establishing cooperatives, but that is the extent of the attention given to the rural sector in the recent past. The lack of past investment or incentives has slowed the development of all areas of agriculture including rice. Some efforts have been made to introduce higher yielding varieties (ca 20% of production), but it was found that while traditional varieties could be dried by hand using sun or ambient air, the new varieties have necessitated introduction of artificial drying. Attempts of farmer and miller to continue to use traditional methods have resulted in increases in outright spoilage. As a result, the government has decreed that by 1980 they will require mills to have silos and driers (all of the South and 30% of the North) and that rice will be brought to 14% for storage. Both the Millers' Association (Asociacion Peruana de Molineros de Arroz, APEMA) and the Government Food Organization (Empresa Publica de Servicios Agropecurarios, EPSA) independently estimate the outright losses to be about 10% after harvest. They hope to reduce this type of loss to near 2%. The Millers' Association has a project to study all the mills in Peru in light of the 1980 regulation to determine what the drying needs of each will be and to obtain financing for the purchase of required equipment. Information is being supplied largely by consultants and by salesmen from commerical drier manufacturers.

Threshing

In the north coast areas, combines are used but field drying is still common. In the south, threshing by running a tractor in circles over piles of rice is said to be common. In the jungle, rain is a problem and hand threshing (beating) is common. The rice is sold at the mills to the government. The mill tests the rice for the government for milling quality, foreign grains, and moisture, charging discounts, and finally issues a certificate to the farmer for his rice (warrant to the government) which the farmer redeems for cash. The prices were just increased to provide incentive for increased production (from 15.7 to 29 solis for the jungle (higher due to drying costs per kilogram). Delivery to the mill ends the farmer's interest in the rice.

Drying

Drying has been either field drying, yard drying, partial field drying and open bin storage drying (described below), or some type of artificial drying (used until now only in the jungle). Field drying is done by the farmer, the rest at the mill. Open bin storage is bulk storage in large open bins or "rooms" holding 1000 to 3000 tons at a depth of 4.5 meters. The tops are open to the air, the sides, concrete and the floor, wood but covered with jute sacking to provide softness to reduce caking in the bottom layers of rice due to pressure. The rice may be taken out to drying yards (Arequipa) and returned, but often it is simply constantly turned by laborers in the bin to allow the air to reduce the moisture. Traditionally, rice at 18 to 20% moisture is dried outside to 15 to 16% then kept in bins where it dries lower. Actual moistures can be higher, inviting losses, and the constant handling also causes losses (the bottom rice layer of the bin must be chipped out). Drying in the jungle area is said to consist of placing sacks on a rack over a plenum chamber through which heated air is forced. Petroleum is the fuel used. Since the rice arrives at 18-24% moisture, the need for artificial drying has always been present in this area.

Parboiling

None in Peru.

Milling

The government requires 68% yield of rice from paddy and the miller is paid on this basis with premiums paid for yields exceeding 73.5% and for higher quality. The yield level has been raised from 66% in 1971 because the newer varieties have been giving higher yields at the mill (actually 68-70%). Mills are for the most part of moderate size (1 to 3 MT/hr), although smaller (0.3 MT) and larger (10 MT) also exist. They are most likely domestic commercial of the type seen elsewhere in South America, and judging from the reputed yields, operated competently though perhaps not always to best advantage. (The itinerary did not allow visits to mill or growing areas in Peru).

Other

Rice is such a political item in Peru that a thorough loss study would probably not be encouraged. Exact figures on any phase of processing are not

obtainable at this time or in the near future. However, the government and private rice people are interested in reducing losses. The project by the Millers' Association is the type which could be viable in Peru.

Capital is in short supply, partly due to earlier waste. Competent management is also scarce. Except for the apparent good use of varieties in some areas, there has been no reasearch or investment in improvement of the rice system. Government attention has focused on urban areas in the past, although some change in this policy may be occurring. There is no postharvest research program at present, though research facilities in other areas of technology exist near Lima. AID has some proposals for bran stabilization and oil extraction, but again these require capital and management. Peru seems to have the potential for a good modern commercial rice system using medium sized equipment.

EPSA, the government agency which purchases rice from the farmer and monitors the entire postharvest rice system in Peru, agreed to compile a report of rice losses drawing on data in reports which they routinely obtain in their course of business. The summary table is below. The report indicates their belief that it is not possible to discover exact figures for the various stages of processing because conditions affecting losses are dynamic. Instead, they describe the factors responsible for losses and an estimated range of loss for each phase of processing. Besides the political pressure mentioned above to avoid fault-finding associated with pinpointing losses and quantifying them, which is present in many countries growing rice, there is a genuine concern on the part of EPSA and other Peruvian agencies that time, effort, and money might be wasted on gathering somewhat artificial loss data and that the efforts and especially the money, might be better expended to reduce the losses without knowing their exact level. The authors believe the objection to be legitimate and advise caution when dealing with loss figures (or when setting out to gather loss data); nevertheless, they believe that some sort of loss estimate based on actual sampling would be useful as part of any overall loss reduction program, even in Peru.

Table I. Possible Losses of Rice, Theoretical Estimated Percentages

Paddy (%)				Milled rice (%)		
Harvest						
Reaping	Threshing	Transport to mills	Storage at mills	Processing at mill	Transport to storage	Retail Storage
2-3.5	1.5-2.0	0.5-1	0.5-1.5	0.2-0.5	ca. 0.5	0.5-1.5

Overall average losses: about 6-10%. NOTE: Bird losses before reaping can be up to 20% by weight.

ECUADOR

General Discussion

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	83	101	135	95	85
Yield - MT/ha	2.75	2.39	2.39	2.58	2.15
Production - ThMT	228	241	322	245	183
Milled - ThMT	137	145	193		
Imports - ThMT	2	21	20		

There are three agricultural areas in Ecuador, (1) the dry, warm flat coast where 95% of the rice is grown, (2) the high Andes mountain valleys where very little rice is grown, and (3) the jungle where no rice is grown but which is said to have high potential as a rice area. Almost all of the rice is grown in the areas immediately surrounding the town of Guayaquil which is the flood plain of the Daule river. Two crops are grown, both irrigated, the first by the help of rains, the second by pump or simply retention of water from earlier rain or flooding. The lack of water limits the second crop especially for the smaller producer who does not irrigate mechanically. About 60% use hand methods including transplanting, about 35% use irrigation and mechanical methods but still depend on the rains, and 5% use very modern equipment pumping up water from the river whether it rains or not. These percentages describe also the relative size of the farms, 60% being less than 5 hectares, and only 5% being over 100 hectares. The quality of production of rice has been declining in recent years in spite of generally favorable growing conditions. Part of the problem is complete lack of infrastructure not only in the rice system but in every way in the rural area. Transport is nearly impossible during the wet season and agricultural transport is difficult for the small operator even during the dry season. Other problems include mixed varieties for seed, diseases, imports of rice arriving at harvest which depress prices, extremely high cost of chemicals and lack of credit. On the positive side, even the smallest grower has enough rice to eat (all are attempting to be commercial producers), and drying is not a problem. Storage at the farm as well as mill level is common with protection from predators being the major problem. Official prices are established by various government agencies for the different steps in the market chain, and the government does buy, mill and sell rice to the public at these prices. However, there also exists a free market which may be at somewhat different prices. Also, middlemen are active at most levels. The National Storage and Marketing Agency (ENAC, Empresa Nacional de Almacenamiento y Comercializacion) buys, mills and sells rice (perhaps 40% of the total crop) to one customer, the National Agency for Regulating the Marketing of Certain Vital Products (ENPROVIT, Empresa Nacional de Productos Vitales) which sells to the public through its own wholesale and retail outlets. They seem to operate at a profit and still offer the farmer a better price than he can get elsewhere at peak of harvest. The buying of rice by ENAC is done at the field with a moisture meter and a check of impurities. The only quality factor is the variety and length of grain. The farmer is paid by check or, if amount is small, by cash. Storage is in tents, outdoors in rented warehouses and is generally poor at peak of harvest because of exposure to the elements. ENAC also gives some of the purchased rice to private mills for custom milling. EMPROVIT

classifies private mills according to how much they must sell to EMPROVIT, 500, 200 and 100 cwt per month, which is probably in addition to the amount of rice obtained directly from ENAC. Prices at all levels are constantly changing due to changing conditions. A third agency actually controls the prices and all other aspects of licensing of private mills, the National Rice Program of the Ministry of Agriculture. The Program also serves as extension and source of information for the millers and others in the rice system.

Threshing

Threshing is done by combine by large farms, by rented combines, by groups of small farmers, or by hand by those unable to rent. No mechanical threshing is done alone. Opinion was that small mechanical threshers would not be useful because those not using combines would also be unable to use them.

Drying

As mentioned above, Ecuador is one of the only countries where drying is said not to be a problem. Mechanical driers are used, but the climate also favors sun drying. In fact, the field drying before harvest may actually be severe. Storage is sometimes in the open, and even when in buildings, the rice is often not protected.

Parboiling

No parboiling in Ecuador.

Milling

ENAC has one mill of about 20 MT/hr capacity which is the largest mill in the country. It is a Sataki package about a year old. The other mills (about 2000) cover the range from less than 5 MT down to the very smallest possible. Every brand seems to be represented. Wooden accessories such as paddy separators are made in Ecuador, the domestic wood being of very good quality. The government is considering outlawing the very smallest mill (Engelberg type), but extension people think this is a mistake because these mills have replaced hand pounding, and they keep the people who are dependant on them from being exploited. There are an estimated 100 to 200 of these mills in the mountain rice areas. Repair of all of the mills is a problem. Lloyd Johnson tested a Japanese home mill (rubber roll sheller and friction whitener) on several varieties while he was at CIAT (Colomibia) and obtained yields above 70%. He suggests also that such small mills may have a good future in Ecuador and other similar situations. The criticism that the wear of these mills restricts their use was countered by the thought that other types of mills wear also, and their parts may be more difficult to obtain than the Japanese (or similar).

Other

Ecuador has ideal growing conditions for rice and an ocean port immediately adjacent to the growing area. It has some oil which provides the government with working capital. Rice drying problems which plague many other developing

countries do not threaten the Ecuadorean rice crop. Yet problems exist in almost every sector of the system causing imports, official and unofficial, from nearby Colombia almost every year.

Much of the problem is the result of the general lack of development of the social infrastructure, of the political and economic supports, and of the technological capabilities. Improvements have been made in many areas, but progress has not been consistent. Projects supported by donating agencies of several governments include (1) a study of soils and agricultural mapping by a French group in the Ecuadorian government, (2) Rockefeller Foundation support of INIAP (Instituto Nacional de Investigaciones Agropequarias), the Ecuadorian research group which produces rice seed, (3) AID sponsored programs to assist improvement of research, extension, and education (rice technology), and (4) CeDeGe (Comision de Estudios para el Desarrollo de la cuenca del Rio Guayas), projects for the development of the Rio Guayas area. CeDeGe was founded in 1965 by petition of the Organization of American States to produce studies concerning the entire general development of the area. The AID program includes two contracts with U. S. universities, the first from Kansas State University (Robert Julian, team leader; Charles Deyoe, and Cornelius Hugo), and the second with personnel from Oklahoma State and University of Missouri headed by Frank Baker, OSU. The KSU contract is a regional one to set up education programs suitable for technical personnel working with grains and to study losses (proposed). The other focuses on Ecuador, in particular, problems of storage, processing, and the possible establishment of a small cooperative. AID has observed that much of the present extension and other government support benefits mostly the largest producers. The activities of the University study groups should provide some of the most up-to-date information on postharvest activities in the area.

General Discussion

The West Africa Rice Development Association (WARDA) is engaged with research and production projects, and provides assistance in the rice postharvest sector to reduce losses and raise the nutritional and quality standards of milled rice. Within the framework of this latter program, WARDA has carried out a survey in member countries of the post-harvest technologies including details of equipment used. The survey was by Van Ruiten of SEARCA, Philippines, and was completed in 1977.

A general inventory has been made by carrying out studies in 13 individual countries and by using a standard information format. Limited data have been collected on harvesting, threshing, winnowing, drying, storage, parboiling and milling. The data include time of operations, methods, equipment and capacity of equipment. The countries are believed to be: Liberia, Sierra Leone, Ghana, The Gambia, Senegal, Benin, The Ivory Coast, Nigeria, Mauritania, Mali, Upper Volta, Niger, and Togo.

A major problem at the farm level has been found in most of the WARDA countries: i.e. inappropriate harvesting and field handling practices which cause serious postharvest losses and the milling of low quality rice. WARDA has recommended that priority should be given to training programs for production and extension workers to prevent quality deterioration at the farming level, and to gradually introduce quality standards both for paddy and milled rice.

The survey further identified that development work is required to improve rice parboiling, milling, and the maintenance of equipment.

While the authors were unable to visit all of these West African countries during this state-of-the-art survey, limited in-field studies were carried out in Liberia and Sierra Leone.

LIBERIA

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	200	220	220	205	210
Yield - MT/ha	.93	.91	.83	1.27	1.31
Production - ThMT	185	200	183	260	275
Milled - ThMT	120	130	119		
Imports - ThMT	26	28	35		

The staple food of Liberia is rice, produced traditionally as a rainfed (upland) crop harvested once a year. Rice is stored as paddy for 9 - 12 months. The total consumption of milled rice is some 160,000 tons, of which about 40,000 tons is imported. The Government's policy is to increase local rice production, with a target of self-sufficiency in 1980. Of the total local production of about 245,000 tons of paddy, it is estimated that 75 - 80% is retained on farms for self-consumption. Of the 40,000 - 50,000 tons marketed, less than 10% passes through the Government-controlled marketing channel, the Liberian Produce Marketing Corporation (LPMC). The balance of 35,000 - 45,000 tons is handled by small private traders. Monrovia, the capital is supplied mainly by imports, taking about 50% of total imports.

The average farm size is 3.5 acres, and mean paddy yield is 800 lb/acre.

Threshing

In traditional upland cropping harvesting, threshing and cleaning are entirely manual. Heads are cut individually with a knife and bundles of panicles after a period of field drying in heaps, are stored in the roof space ("kitchen top") above cooking area. Heat and smoke from the fire help to dry the paddy and discourage insect attack. In spite of this, the moth and rice weevil are known to attack stored paddy and losses due to rodents are stated to be significant. Threshing is by trampling, or pounding with the wooden pestle and mortar used also for milling. No survey of loss in actual processing steps has been conducted.

In swamp rice cropping harvesting by sickle and threshing and cleaning by hand or foot operated machines are being introduced. The increased quantities harvested, often during periods when sun-drying is difficult, indicate the need for better drying arrangements.

Drying

Virtually all rice is dried by sundrying. The LPMC has one drier at their rice mill in Voinjama, though they stated it was not used to dry rice paddy, rather it was used only when the relative humidity was excessively high during a milling run. It was stated that a number of small batch-driers donated some years earlier by a Taiwan Agricultural mission remained unassembled. At the agricultural research station, Suakoko, a columnar drier is installed of an estimated 1 ton/hr capacity. The drier is equipped with a bin on top so that the paddy can be recirculated and be provided tempering time.

Parboiling

The extent of parboiling in Liberia is not known, though it is practiced only at the village level with freshly harvested paddy. There are three methods of parboiling according to Van Ruiten: (a) soaking overnight in cold water, draining off the water, adding a small quantity of water and heating over a fire until all the water is evaporated, and spreading the paddy on the ground to dry; (b) soaking in cold water 24-48 hours, bringing to a boil, cooling, draining, and spreading out to dry; (c) mixing the paddy with water (about 1/4 of paddy volume), boiling the mixture for about 1 hr, and drying the paddy in the sun.

Milling

Rice consumed on the farm is milled predominantly by handpounding. Marketed paddy is bought by "brokers" acting for private traders, or by private or operative agents of LPMC. In either case the quality of paddy presented for milling is extremely low, with a high percentage of contaminants, including earth and stones, and very commonly a mixture of varieties. Since the milling characteristics of swamp and upland varieties are entirely different, overall milling recovery is reduced. Estimates on the number of private mills vary widely. LPMC estimated 150-200 rubber roll sheller/friction polishers and up to 400 Engleberg hullers. Van Ruiten estimates 150 Engelbergs, and 90 rubber roll sheller/friction polishers mainly of the Kyowa/Yanmar type. In some cases a rubber roll sheller is used in conjunction with an Engelberg employed as the polisher. The Engelbergs are mainly Grantex (U. K.). Using Van Ruiten's estimates, the quantity of paddy milled per machine per year is estimated at 150-200 T, or 36,000-48,000 T total. Each milling system has a 1/4 TPH capacity. Figures calculated from data supplied by custom millers in Gbarnga indicate a rice yield of 59-63% on the Engelberg single-pass miller operation, and 64% on a rubber-roll sheller - Engelberg polisher combination. Custom operators stated that maintainance of the rubber roll operations was expensive, particularly rubber roll replacement costs. One miller estimated rubber roll replacements were required after milling of 4 tons of paddy if 100% hull removal, 5 tons of paddy at 80% hull removal, and 5.5 tons if 70% hull removal. The mills operate on custom milling basis, currently charging 1 cent (US) per lb of paddy, or $22 per MT.

One county coordinator (Ministry of Agriculture) stated people preferred Engelbergs even though the other system gave better yields. He estimated the degree of milling at 4%. Recovery of white rice from the mills was thought to be less than that from hand-pounding, though women were observed successfully screening out the larger broken fragments from the milling by-products.

Based on a theoretical yield of circa 70%, at a 4% degree of milling, it would appear that losses in rice during the milling process lie between a low of 8% (rubber roll system, 64% yield) and a high of 16% (Engelberg, 59% yield). None of the custom mills have paddy destoners (cleaners). Severe defects (holes) in the screens of Engelberg hullers were observed due to stones and/or wet paddy. Such holes undoubtedly further aggravate losses of broken rice.

Only three commercial rice mills exist in Liberia, all owned by LPMC. The systems comprise precleaner, rubber roll sheller, husk aspirator, paddy

separator and whitening cone. They practice 6% degree of milling with a milling yield of 62-68%, though actual throughput is low, 6,500 MT in 1977.

Liberian observations indicate milling techniques to approximate: hand-pounding, 77% small mills, 20%, and large mills, 3%.

There is no rice grading, and thus no incentive to improve milling quality in Liberia. Neither are there procurement incentives for better quality paddy. Probably as a result of WARDA being headquartered in Liberia, the government is committed to a policy of self-sufficiency in rice. As part of this program the government has established a Technical Coordinating Committee which will promote, coordinate and monitor all activities, aimed at reducing postharvest losses of rice. Within this context, FAO has placed a project in Liberia to initiate work on reducing losses during harvesting, drying, storage, threshing, and pounding. The project will include training courses on paddy grading. The project, PFL/LIR/78/01, July 1978-June 1980, is entitled Reduction of Postharvest Rice Losses in On-Farm Operations and Primary Marketing. The FAO coordinator is Kenton Harris, USA. Reduction in losses will be (expectedly) brought about by introduction of "simple equipment and techniques".

SIERRA LEONE

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	351	370	370	390	400
Yield - MT/ha	1.36	1.43	1.43	1.54	1.48
Production - ThMT	479	530	530	600	590
Milled - ThMT	307	339	339		
Imports - ThMT	2	14			

Sierra Leone is the most important rice producing country in West Africa, with about 7% of the total African production. Rice is the staple food in Sierra Leone with over 50% of total food availability being available as rice. Per capita rice paddy production was 174 kg/capita in 1976. Estimates suggest that there are 286,000 small farmers with an average holding of 4.5 acres (6-20 crops per holding), 70% of whom grow rice, though only 22% have a rice surplus to sell. About 63% of all cultivated land is planted to rice.

Van Ruiten and Rozeboom have provided a comprehensive breakdown of rice post production technology in Sierra Leone. Elsewhere, Spencer _et al_. have described the economics of rice processing with an emphasis on employment. The latter study developed an economics model which is recommended as a basis for selecting future rice milling machinery in Sierra Leone. The model, which incorporates elements of models previously described for measuring social impacts of intervention programs, measures the implications for employment and income distribution as a consequence of intervention techniques in the rice milling industry.

While no accurate figures are available for losses in total edible white rice (or parboiled rice) occurring at individual stages of postharvest processing, scientists at the Rice Experiment Station, Rokupr, indicated that they plan to assess losses at each stage of the harvested rice-to-consumer sequence, during 1979.

Rice recovery rates from paddy as a function of milling equipment, and from hand-pounding have been gleaned from the report by Spencer _et al_ and are presented as follows:

	Rice recovery (%)		Brokens (%)	
	White	Parboiled	White	Parboiled
Hand pounding	68	69.4	47.4	31.7
Engelberg steel huller	64.5	67.7	36.4	16.7
Satake Rubber roll	67.0	73.6	43.5	3.2
Disc-sheller (large commercial mill)		62 av		5-10

If one assumes Spencers' data to be correct, one can estimate the "implied loss" through widespread use of Engleberg type mills, which produce a net rice outturn of about 3% (white rice) and 7% (parboiled) less than units incorporating rubber roll dehuskers.

Threshing

At the farm and village level, harvested grain, which may have been cut and stacked either 1-3 days or 1-4 months in the field, is threshed by foot treading, beating with sticks, pounding in a mortar, or occasionally on the ground by using pedal threshers. While the government has imported about 100 pedal threshers, the farmers' response to purchase and use of them has been poor. No animal supported threshing is practiced, nor are there any stationary or mobile mechanical threshers.

Winnowing of threshed grain invariably includes dumping the grain on open soil. This results in the presence of stones in the paddy and consequently, eventual damage to milling equipment.

Drying

In cases where the harvested rice has been stored in the field for several months, ambient moisture conditions are gradually reached by the paddy. However, where the harvested rice is not stored for a long period, the paddy threshed and winnowed on the farm is normally not dry. Yet, in general, no sundrying after threshing is practiced, and the grain is bagged moist. Nevertheless, all paddy is dried eventually before milling, through sundrying, either before home consumption, or before village level milling.

Sundrying is practiced by spreading thin layers of paddy on small cement surfaces, on asphalt roads, or on level soil. Mechanical drying of paddy is not practiced at the farm, village level or commercial level (though it is on parboiled paddy at the commercial level), when these mills are operational.

It is obivious that storage of paddy in the field as unthreshed sheaves for 1-4 months exposes the grain to damage from water, rodents, birds, insects, and microbial attack, and to pilferage. Mechanized drying with adequate storage of dried paddy would negate these losses.

Parboiling at Village Level

Parboiling of paddy is a widely accepted practice in Sierra Leone, and three main reasons for parboiling have been recorded when interviewing farmers and villagers. These are: (1) parboiled paddy is much easier to dehusk by hand-pounding; (2) parboiled paddy produces more rice in pounding or milling because it is less prone to break; (3) during cooking, the volume of parboiled rice increases considerably more compared to nonparboiled rice. Parboiling is never done before storage. Only the quantity of paddy to be consumed shortly afterwards is parboiled. A batch varies from 3 or 4 kg to about 60 kg. Two parboiling processes were recorded:

A. Paddy is soaked in cold water overnight. The water is drained off in the morning, and about 1 cm of water is then added, the pot or drum is put over a fire and the paddy is steamed until all the water evaporates. The paddy is then sundried and hand-pounded.

B. Paddy and water are brought to a boil, the fire is extinguished and the drum is left overnight. The following morning the same steaming procedure as mentioned under A is followed.

Parboiling at the rice mills

Parboiling is not practiced at village mills, although it is at three commercial mills. The three rice mills owned and operated by the Rice Corporation at Kissy, Mambolo and Torma-Bum, are provided with parboiling facilities. A complete description of the equipment is summarized in WARDA documents.

Milling

Rice Milling at the village level: Three types of village mills exists in Sierra Leone.

(1) The Satake single pass rubberroll huller combined with friction whitener, model S.B.-2B. This machine has a paddy intake capacity of about 200 kg/hour with a milled-rice recovery of about 63% on pure paddy. Most of these machines are driven by a 6 HP electric motor or 8 HP Kubota diesel engine. Somewhere between 20 units (estimated by Van Ruiten) and 50 units (estimated by Spencer et al.) are in operation currently.

(2) The Satake single pass rubberroll huller, combined with friction whitener, model SB-10B. The capacity of this machine is about 500 kg of paddy per hour. The milled rice recovery varies between 63% and 66% on pure paddy. Some of these machines are installed in combination with the small Satake precleaner, model BC-05B. Most of the SB-10B machines are driven by a 20 HP electric motor or a 25HP Lister diesel engine. The Rice Corporation has two of these machines at each of the Kissy, Mambolo, and Torma-Bum plants.

(3) The Grantex No. 1 steel cylinder huller/whitener, normally supplied with polisher and sometimes a fan. Neither the polisher nor fan is used by any of the mill operators and they are always by-passed. There are approximately 350 units of this type of machine operational in Sierra Leone. This machine has a paddy intake capacity of about 200 kg/hour and a milled rice recovery of between 57 and 60% on pure paddy. It is considered locally (May-Parker, unpublished info) that this overall performance can be improved through better adjustments. Most of these machines are driven by either a 20 HP electric motor or a 20 to 25 HP diesel engine. About 95% of these machines are of UK origin and about 5% are of West German (Schule) origin. However, the design is identical and parts are interchangeable.

Spare parts most often required are rubber rolls, and screens for the Engelberg mills.

The average village mill operates at about 37% of theoretical capacity. These mills follow a seasonal pattern, peak operation occurring after the harvest season (November-February), milling approximately 6 hours daily, 6 days per week, while the remainder of the year, mills operate only about 1 hour per day.

The Satake and Grantex mills are imported and distributed by Commercial Enterprises, and Abess Brothers and Sons, respectively, of Freetown, Sierra Leone.

Commercial mills are located at Kenema (privately owned) and Kissy, Mambolo, and Torma-Bum (all owned by the Rice Corporation, a government body). Complete details on these mills, and their equipment, and capacities, etc. are outlined elsewhere (Van Ruiten). During the period 1968 to 1974, the three Rice Corporation mills combined processed only 4000 MT/year, while the Kenema mill was not yet operative. During this survey, none of these large mills was operating. It is believed by the authors that this is due at least in the Rice Corporation mills, to (a) poor management (b) dictating uneconomically low rice paddy purchasing prices, and (c) a deliberate policy not to mill rice and thus sustain the (entrepreneural) need to import milled white rice.

In summary, rice milling methods comprise hand-pounding (83%), village level milling (13%) and commercial level milling (4%), though during 1978 for example, the latter was zero.

OTHER WEST AFRICAN COUNTRY SUMMARIES

Rice postharvest handling data for some other West African countries are summarized below:

Country	Threshing[1]	Mechanical[2] Drying	Milling practiced, %		
			Hand pounding	Village mill[3]	Commercial mill[4]
Benin	manual only	some	30	30	40
Gambia	manual, some pedal	very limited	92	6	2
Ghana	manual, some pedal limited mechanical	none	62	24	14
Ivory Coast	manual only	some	46	31	23
Nigeria	manual only	very limited	92	6	2
Senegal	manual, some pedal	none	not available		

[1] No animal threshing practiced
[2] All practice sundrying
[3] Predominantly U.K.- Engelberg types
[4] Japanese rubber roll dehusker--friction whitener or Engelberg whitener

EGYPT

General

	73/74	74/75	75/76	76/77	77/78
Area - ThHa	450	490	490	484	437
Yield - MT/ha	5.05	4.58	5.10	5.20	5.20
Production - ThMT	2,274	2,242	2,500	2,519	2,272
Milled - ThMT	1,524	1,502	1,675		
Imports - ThMT	---	---	---		

Although the authors did not visit Egypt during this state of the arts survey, one of the authors carried out work in Egypt earlier in 1978 on behalf of FAO. Some facts pertinent to the present study have been extracted from his report and are included as follows:

Egypt is the largest producer of rice on the African continent. The total production of paddy in Egypt is about 2.4 MMT a year. Over the last three years, 1 MMT (40%) of paddy produced per year has been milled in the commercial (government) sector and 1.4 MMT (60%) in the private (farm and village level) sector. The farmers growing the paddy are obliged to furnish 1.5 MT per feddan to the government collection agency at a fixed price. The balance of the paddy production is retained by the farmer and is usually milled in a village huller (Engelberg) mill for either the farmer's own use or for private sale (which is illegal).

The eight government-owned rice mill companies (54 rice mills) are equipped with traditional systems. They produce the separated products, rice, husk, bran and germ. These mills are optional for about 7-8 months in a year and have a country-wide total handling capacity of about 5000 MT/day. They are nationalized and receive the paddy from government purchased stocks.

Some confusion as to the actual milling out-turn is evident in these 54 commercial-scale mills. There has been considerable disagreement concerning the disposition of the so-called 8 percent rice bran calculation. It is believed that the rice for local consumption is deliberately undermilled to about a 6 percent plus figure, which reconciles with the actual amounts received by the oil extraction plants, and that the additional weight on the export portion is lost in the hull stream as floured brokens instead of being salvaged with the bran. It appears that a 2 percent loss of rice into the hull stream is conservative. Two percent corresponds to a net loss of edible rice during milling of about 3% (at 65% white rice recovery rate). The 16 percent hull percentage is fairly accurate on the japonica types comprising most of the milling. The best estimate of out turn on a multi-year average and based on 100 percent of paddy weight, shipped moisture basis is given below:

68% white rice
16% rice hulls on japonica milling
6% rice bran on an actual milled basis
4% mud balls and other dockage

2% brokens to starch and reds
2% rice germ
2% losses - mostly into hull stream

About 60% of all rice paddy is handled privately by the huller (Engelberg-type) mills which are located in the villages. Generally in these huller mills, only one by-product, a mixture of ground hull, bran and finely ground rice, is produced. This "huller bran" is used exclusively as animal feed, usually by the farmer for his own animals. Occasionally it is sold by the farmer in a local market. No accurate measurement of white rice content in the huller bran has been recorded, though the authors would expect it to be the same as encountered in single-pass Engelberg mills elsewhere.

The main season for rice milling lasts 7 to 8 months each year; harvesting os carried out from November through March. There exists adequate capacity in Egypt, at both the village and commercial level, to mill and distribute the current production of paddy.

The acute food shortages, and malnutrition in Egypt underline the urgent need to reduce rice postharvest losses. Paradoxically, in Egypt, since about 20% of all rice is exported for hard currency, which in turn is used to purchase cheaper though nutritionally equal wheat, reduction in rice losses (and increased amount of export) at the government mills theoretically would bring about an even greater increase in available edible foodstuffs.

The Food and Agricultural Organization of the United Nations (FAO)

The following is excerpted from the FAO Bulletin W/L2783, (January 1978), FAO Action Programme for the Prevention of Food Losses, Guidelines and Procedures. (A. A. C. Huysmans is the FAO (Rome) coordinator for the postharvest losses program).

I. BACKGROUND AND BASIC PURPOSE OF FAO'S ACTION PROGRAMME FOR THE PREVENTION OF FOOD LOSSES

The Nineteenth Session of the FAO Conference held in Rome in November 1977 approved the Director-General's proposal[1] to establish an action program for the Prevention of Food Losses to be financed from a Special Account created for this purpose under the provisions of Financial Regulation 6.7. The execution of the Programme is in line with the basic mandate given to FAO in Article I.3 (a) of its Constitution. This is also one of the ways in which FAO can respond to the Resolution No. 3362 (S-VII) of the Seventh Special Session of the General Assembly of the United Nations, which stated that postharvest food losses in developing countries should be reduced by 50 percent by the year 1985. When the Programme is fully established, it is hoped that the annual disbursement from the Special Account will be of about US $10 million and that this will be made up of voluntary contributions of Member Governments as laid down in the Resolution 3/77 of the Nineteenth Session of the FAO Conference. The Director-General is reporting separately to Member Governments on the status of the Special Account.

The national activities in most developing countries for the prevention of food losses must be considerably increased, if the above mentioned target of a 50% reduction is to be achieved. While most countries have programs to "Grow more food" few have initiated national campaigns to "Save food". The first element, therefore, of a country's policy in food loss prevention must be a commitment to reduce losses, establish a national plan of action, and provide resources necessary to implement the plan.

The basic purpose of the Action Programme is to assist developing countries in their effort to identify the food losses which occur throughout the postharvest system and to plan and implement national food loss reduction programs. The Action Programme will be composed of direct action projects such as improving farm and village storage structures; designing, constructing and managing pilot warehouses; providing small scale grain driers; improving processing facilities; improving rodent control and training at all levels in all aspects of postharvest loss reduction. The mechanism for implementing the programme will be rapid, simple, flexible and capable of expansion. The improvements to be introducted will not only be simple and practical but primarily based on the use of local materials.

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[1] Document C 77/19 Prevention of Food Losses

In formulating the FAO Action Programme for the prevention of food losses, certain priorities and areas of action have been selected in order to achieve a significant impact within a limited period of time. Firstly, in its initial phase, the programme will concentrate on reducing post-harvest losses of staple foods--food grains, roots and tubers. These foods form such a high proportion of the diet in developing countries, and present efforts to increase their production are so intensive that similar effort is justified to ensure that the food produced is not lost during and after harvest. Secondly, priority should be given to the least developed countries (LDC), most seriously affected (MSA), and food priority countries (FPC), and within these countries to actions which will benefit the rural poor - small farmers, villagers and small-scale processors and craftsmen. Thus the Programme will, at the same time, increase the amount of food available and improve the living standards of the rural poor.

Direct action to reduce losses can take place only within countries as part of national programmes for food loss reduction. It is recognized that the funds required to implement all national programs will have to be mobilized over a number of years through assistance from multilateral and bilateral agencies and will amount to several hundred million dollars. The Action Programme being undertaken by the FAO will be made up of selected national projects which are considered typical of the actions countries will wish to take and for which external funding will be required and justified. The projects and the facilities to be provided through them will, therefore, act as models to be expanded or repeated elsewhere in the country itself or in other countries where similar problems exist. Assistance through the FAO Food Loss Prevention Programme will be provided in the form of grants.

The FAO Programme is to be considered as an initial programme only to stimulate further assistance and investment for bigger programs required to meet national needs. Some of the projects, however, will solve immediate problems, each project serving as a springboard for development and generating further action to improve the income of the small farmer, thus, the provision of farm bins, of small driers, and of village cooperative stores should lead to the general improvement in marketing organizations of both outputs and inputs. It is recommended that inputs supplied through the project to farmers and cooperatives will be charged for by the Government and funds thus generated used as working capital to expand the Programme in other areas of the country.

Elements of the Action Programme

The Action Programme will assist Member Governments to initiate or strengthen activities under national food loss reduction programs. It is anticipated that the main elements of the Programme will fall under the following broad headings:

a. Food Loss Assessment Surveys. As the basis for action programs for food loss reduction, governments may require assistance in undertaking food loss assessment surveys. A standard methodology has been developed in close cooperation with other interested international agencies and technical institutes.

b. Practical assistance to combat losses at various stages in the postharvest food systems. The initial loss assessment surveys will indicate the points where the major losses occur in the food system of each of the major crops. Practical assistance, both technical and economic, may be requested by governments to improve the harvesting; drying; winnowing/threshing; storage at farm, village or community level; primary and secondary processing; and in pest control, product handling, transportation and market organization, as may be found necessary.

c. Training. It is frequently recognized that there is a lack of adequately trained manpower at all levels, from the skilled worker to the middle and higher level technologists, managers and research and development workers in the developing countries. Governments could, therefore, call on the Action Programme to assist in the preparation of appropriate manpower development plans; to organize in-country technical and professional training courses; to arrange for the specialized training of key technicians, trainers and research workers.

d. National focal point for food loss reduction programmes. In order to implement national food loss reduction programs, many governments have, or will need, to establish a central technical support/coordination unit or similar focal point. This mechanism within the Government will coordinate all matters relating to postharvest food loss reduction questions. Governments may call on the FAO Action Programme for assistance in establishing or strengthening such focal points.

e. Research, Development and Information Programmes. While the bulk of the resources of the Action Programme will be devoted to direct impact projects, research, development and information programs are important elements of national food loss reduction programs. Therefore, the Programme can be asked to assist in catalytic and prepatory activities which would lead to the strengthening of national institutes or leading to the establishment of regional, subregional or zonal institutes to undertake research in postharvest technology; to facilitate exchange of research and development findings amongst research and extension workers; and to assist in the coordination of the research, development and information programs.

In effect, what is called for in this program of action is a general campaign not only waged on a number of fronts but also motivated by a determination which has been lacking in the past but must be created, and more importantly, sustained. World food production, despite the increase in the application of improved agricultural production technologies, is not keeping pace with the food demands of a rapidly increasing world population. It is therefore essential to sustain every effort to reduce the considerable food losses throughout the postharvest food systems.

FAO has approved the following criteria:

--the project should have high priority in a country's Programme for Food Loss Reduction;

--the activities proposed should have direct impact in reducing postharvest losses of staple foods;

--priority should be given to the needs of the least developed, most seriously affected and the food priority countries;

--the main project action should be completed in 1-1/2 to 2 years;

--training programs should be of short duration, conducted within the country and directed towards farmers, storekeepers and operating staff;

--facilities to be provided should be simple to construct and operate and be of appropriate design and materials for the country concerned;

--country to provide counterpart contribution of facilities and services necessary for successful execution of projects;

--projects in pilot areas should be capable of expansion, to attract further investment;

--all projects should include loss assessment, in order to monitor progress of loss reduction.

The proposed project activity should be of a catalytic nature, preparing the ground for larger assistance programs supported by other agencies of filling a vital gap in relation to the Government's on-going or planned development activities in the field of postharvest food loss reduction. The supply of equipment or other materials and inputs cannot be considered in isolation but must be linked to a specific and clearly defined food loss reduction activity.

Besides the Government attaching highest priority to the proposed project, it is important that the project fits logically into the country's overall food loss reduction program; that local support and follow-up arrangements are adequate and clearly defined; that the execution is possible within the time limit; and that the project is expected to have a marked impact on the prevention of food losses and on the well-being of rural masses.

FAO has recommended areas of activity where external assistance and cooperation could be provided on a collective or component basis. These comprise:

(a) Loss assessment
(b) Technology transfer
(c) Manpower training
(d) Disseminaton of information
(e) Seminars and workshops
(f) Establishment of basic infrastructure
(g) Financing projects

In February 1979, the authors ascertained that FAO has assisted Bangladesh, Indonesia, Laos, Malaysia, Nepal, Sri Lanka, Vietnam, Philippines, and Liberia in developing or supporting projects on reduction of food losses, believed by the authors to be mainly rice projects.

The emphasis of assistance from FAO, though not exclusively, will be upon drying and storage.

AUSTRIA

United Nations Industrial Development Organization (UNIDO)

In discussions with E. D. Manning and H. Koenig, it was stated that UNIDO has current projects directly targeted at reducing rice postharvest losses. One project indirectly concerned with rice postharvest handling was for UNIDO to act as an intermediate party in placing a commercial size rice mill in Malaysia; the mill was donated by the Peoples' Republic of China.

J. A. R. Tainsh, (President, International Business Consultants Ltd.) and E. C. Bursey (Consultant Engineer) in cooperation with R. Hawkey (Consultant) claimed to have designed a new rice dehusking and debranning machine. The machine is claimed to involve new concepts and is not a revamping of Engelberg or rubber roll setups. They claim the dehusker is a new concept using familiar materials. No data were provided except that a 1/2 T/hr pilot scale model built by British Industry, (financial backing by Guiness Peat), would be tested in Indonesia (BULOG). It was claimed that brokens were 2-8% on an (estimated moisture 11-12%) Italian medium grain rice, overall yield 70-72%. The dehusked rice fell by gravity into the debranner, little heat was generated and fuel (electric) consumption was estimated 50% of normal systems. Scientists at the Tropical Products Institute were skeptical of these claims.

IV. SUMMARY

The fact that rice would benefit widely from programs directed at reducing postharvest losses is recognized worldwide. Rice is subjected to more handling and processing steps as it moves from harvest to consumer than other grain products in developing countries. At the farm and village level, little mechanization exists in rice handling, including threshing, drying and parboiling. While considerable rice milling is mechanized, most equipment is either antiquated, poorly designed, poorly maintained and/or grossly mismanaged. The lack of adequate processing equipment is the major contributor to losses. During the state-of-the-arts review, the authors found in most countries that losses were more inclined to be estimates rather than accurately measured values and, as such, could be misstated. Nevertheless, based upon numerous interviews, observations, literature reviews, calculations, etc., the authors believe that losses lie between 10 and 30% and predictably correlate with the degree of sophistication of the rice delivery system in a particular country. Rice loss reductions tend to correlate with the extent of mechanization and, at first glance, it might be considered that the most efficacious approach to reducing losses would be to increase mechanization. This conclusion has been reached by others, and while commendable efforts have been made to introduce improved technology into developing countries by U. S. and other international agencies, only limited success has been achieved, and in the majority of cases, projects have had no impact. This failure can be attributed to (a) inappropriate technology (b) invalid economics (c) inappropriate or inadequate socioeconomic/cultural conceptions (d) inadequate political and financial planning (e) inadequate attention to the degree of sophistication of the rice delivery system as a whole and failure to recognize that it is sophistication that catalyzes mechanization (and reduced losses) and not vice versa.

It is crucial that in any future programs aimed at reducing postharvest losses, those areas listed in (a)-(e) above must be given equal and interdependent consideration to achieve successful implementation.

Losses occurring during threshing, drying, milling, parboiling, and handling appear to account for between 7 and 28% of the rice crop. Even some of the losses during storage can be directly attributable to inadequate drying prior to storage. The lack of drying capability is actually a deterrent to increased crop production.

The status and idiosynchrasies of rice threshing, drying, parboiling, and milling in developing countries is summarized elsewhere in this report. The authors recognize that losses occur during harvesting, storage and other handling phases in addition to threshing, drying, parboiling and milling, and that these losses at a particular stage depend to some extent upon treatments accorded the rice prior to that stage. Because this study dealt only with threshing, drying, parboiling and milling, the authors have listed relevant areas where increased effort could bring about reductions in rice losses.

Threshers: There is no question that mechanical threshers are acceptable to developing countries, particularly to custom-threshing personnel. More rapid threshing, which would displace manual or animal threshing, leads to improved rice yields mainly through the ability to handle more rice rapidly during wet

seasons, that is, rice is not lost as a result of delayed harvesting and unduly long exposure to wet environments after harvesting. Farmers recognize this benefit and additionally welcome the idea of mechanical threshing because it eases the labor shortages caused by the introduction of high-yielding varieties and the shortening of the time frame between crops.

Driers: Rice driers are essentially non-existent in small-scale operations in developing countries; most drying is done by sun-drying. Though IRRI has estimated that losses of 1-5% in overall yield of white rice occurs during the drying phase, this study leads the authors to suggest that inadequate drying facilities is a major causative agent of postharvest losses. The following points are presented in support of this hypothesis: (a) Sun-drying, particularly in wet and humid environments, results in serious rice-kernel cracking. Cracking causes kernel breakage during subsequent milling and losses of small fragments of white rice (the latter alone accounting for a reported 2-10% overall postharvest loss); (b) Losses to animal predators (principally blackbirds) during sun-drying in open places is severe; (c) Inadequate drying causes microbiological problems in paddy rice which result in rice unfit for human consumption, poor quality rice, further breakage during milling, with subsequent losses; (d) Inadequate drying during peak harvesting periods results in rapid deterioration of the wet kernels, particularly in second and third croppings harvested during wet seasons. Losses of second and third crops have been estimated to be as high as 50% due to inability to dry the paddy. Thus, the potential impact of second and third croppings is being needlessly dissipated through these huge losses accruing from lack of postharvest drying facilities; (e) Probably that most important "loss" in rice is that of rice not planted. For generations, farmers have been socially trained to plant rice only at certain times, predictably times which coincide with the ability to harvest and to sun-dry under expectedly reasonable weather conditions. If the farmer has guaranteed drying capability, not only could losses listed under (a) and (b) above be diminished, but additional crops could be planted and utilized effectively. An effective, economically acceptable drier could have a profound impact upon increasing the supply of milled white rice.

Mechanical driers should have a high priority in efforts to reduce rice postharvest losses. It is an established fact that rice harvested at higher moisture levels and dried mechanically gives significantly higher yields of milled white rice. The total yield of milled white rice from rice harvested at 21-24% moisture level is about 1% higher than that from rice harvested at 15-18% moisture. Mechanical driers would capitalize upon this phenomenon.

Husk-fired driers are under investigation in numerous locations, and the technology of husk-burning is reasonably developed. However, it can be argued that straw-burning would be more appropriate for drying rice since the straw is at the farm whereas the husks are at the mill. Since the technology of burning straw is different than that for burning husks, straw-burning furnaces need to be developed.

There has been a great deal of clamor for a natural drying system using neither fuel nor power to be developed for use in tropical areas. While this is a most worthy goal, at the present state of technology, no suitable system exists. It might be well to expend some effort to investigate all past work and determine if any developments could be worthwhile to pursue.

Milling

Milling Systems: Losses in rice because of inadequate milling have been estimated to be between 2 and 10% of the crop. During this study the authors visited numerous farm, village, and quasi-commercial milling operations. Numerous mills and combinations of mills were encountered where, in many instances, claims have been made and are currently made that a particular milling process is the best for that location. These claims are made especially by commercial entrepreneurs and by government, academic and commercial researchers whose very existence and financial support is dependent upon convincing others of their claims. It is recognized by independent organizations such as IRRI, FAO, UNIDO and Tropical Products Institute and USDA that such claims are not validly substantiated. It would be of immeasurable value to the reduction of postharvest losses of rice throughout the world if a properly designed baseline study of the rice milling practices could be carried out under a variety of conditions commonly encountered in the field. The net yield of milled white rice available for human consumption as a function of all rice processing combinations, along with economic and social impact studies would be available for all individuals and organizations involved with rice, now and in the future. Such information would be especially valuable to purchasing agencies in developing countries and to organizations like FAO and UNIDO who may fund purchases of needed rice processing equipment. Indirectly, the results of such a baseline study would encourage manufacturers to concentrate their development efforts in productive channels with the net effect being the manufacture of more efficient and lower cost processing machinery.

Rice Paddy Cleaners: It is evident that inexpensive efficient paddy destoners are nonexistent. Stones and other debris have severe, adverse effects upon rubber rolls in the shellers (dehuskers) and bran screens in Engelberg-type mills. These effects contribute directly to losses in edible white rice during the milling operation. An inexpensive destoner (and paddy cleaner) which would be universal in application (i.e., could be used in conjuction with any type of rice mill) is needed. Such equipment undoubtedly would contribute to reduction in rice postharvest losses and would certainly increase rubber roll and Engelberg mill screen longevity (i.e., decrease processing costs). These changes would be easy to quantify.

Huller Mills: Engelberg mills (huller mills) are omnipresent in developing countries where they are used for dehulling and polishing either in single or double pass operations. They are also used as polishers in series with rubber dehuskers or as dehullers in series with other polishers. Commercial rice millers in the United States who use Engelbergs sometimes employ plastic pressure bars rather than steel pressure bars--claiming less broken rice (which would ordinarily lead to losses in developing countries). The implementation of plastic pressure bars in developing countries and the effect upon milling yield of edible rice should be studied.

The advantages of stacked (series) Engelberg hullers upon rice milling losses have been proven in a number of instances but, in the atmosphere prevalent, this concept has never been followed up. A thorough investigation and evaluation should be done.

Rubber Roll Mills: The use of rubber roll dehullers to remove the husk from paddy rice is becoming more prevalent in developing countries, though the economics in small-scale processing do not appear to be adequately answered. A common complaint voiced from all people interviewed was the replacement cost of the rubber rolls and the high maintenance cost-precision demanded by this machine. Since the rubber rolls wear out rapidly, the roll design and/or roll composition may be modified with a view to increasing roll longevity. Processing costs would be lowered by less frequent replacement of the rolls. Rolls which wear out less rapidly implies less time milling with badly worn rolls, and thus, on an overall yield basis, more dehusked rice of better quality. Dehusked rice of better quality means a better yield of white rice or a decrease in lost white rice compared to present systems.

Parboiling: Specific losses incurred in parboiling rice have not been assessed. On the one hand, milling yields after parboiling are higher than yields encountered during milling of regular rice; thus, parboiling itself can be construed to reduce rice postharvest losses. On the other hand, there is some loss due to predators during sun-drying of parboiled paddy. On balance, however, it is likely that parboiling reduces losses. Although there are questions by serious workers as to whether the gains of parboiling are worth the energy requirement, it is clear that parboiling will continue to thrive, since about one-third of the rice in developing countries is parboiled as a result of cultural preference. It is equally clear that improved parboiling systems will be sought indefinitely. In addition to any nutritional gains brought about by parboiling and to improved insect resistance and increased milling yield (i.e., decreased milling losses), one further advantage is the high quality of parboiled bran which can be channeled into edible oil extraction. Raw bran in developing countries is used as animal feed, fertilizer, or discarded. On the other hand, parboiled bran in which lipase activity is destroyed can be, and is in some places, utilized to provide edible rice bran oil, i.e. food calories in areas which need the calories.

Present parboiling systems in developing countries are rudimentary, usually involving heating in small pots over fires inefficiently producing poor quality rice. Even where some sophistication has been introduced, for example, in India, quality is often very poor. Further effort should be devoted to researching low cost energy efficient parboiling units.

Rice Grading: Probably the most effective means of reducing rice postharvest losses would be to introduce an equitable grading system for edible white rice. Most developing countries have no grading whatsoever. Introduction of a grading system would ensure improved management, maintenance and handling practices in the quest for better quality and profitability. Such endeavors would guarantee reductions in rice losses.

Other: Because it can be easily seen in almost every facet of rice processing, heat or power in some form is needed and that in most situations the requirement is one of the larger deterrents to use of an improved technology, it would seem to be of maximum importance to develop equipment or technology to permit the use of indigenous and locally available fuels for drying, parboiling and as a prime mover. The use of either direct combustion or producer gas equipment has been suggested, and in all parts of the world, hardware and

technologies are being pursued. The work is fragmented and sometimes misdirected. A coordinated effort among institutions working along these lines would produce long-term benefits to the world's rice industry; immediate profits would be ensured on every level of utilization. Specifics should include heating sources for driers at every level and determination of most beneficial designs at each stage.

V. ITINERARY

Asia (Beagle, Wasserman, Mossman)

1978	July	9-12	Japan
	July	13-16	Korea (Beagle)
	July	13-16	Taiwan (Wasserman, Mossman)
	July	16-22	Philippines
	July	24-28	Indonesia
	July	29-August 3	Sri Lanka
	Aug.	3-12	India
	Aug.	13-20	Thailand

South America (Mossman)

1978	Sept.	17-23	Colombia
	Sept.	24-28	Bolivia
	Sept.	29-Oct. 4	Brazil
	Oct.	5-7	Peru
	Oct.	8-12	Ecuador

West Africa and Europe (Saunders)

1978	Oct.	22-24	Sierra Leone
	Oct.	24-28	Liberia
	Oct.	29-Nov. 3	Italy
	Nov.	6	Austria
	Nov.	10-14	England

VI. INSTITUTIONS AND WORKERS VISITED

AUSTRIA

1. United Nations Industrial Development Organization (UNIDO)
   PO Box 707, 1011 Vienna

   Mr. Horst Koenig
   Mr. Eric D. Manning

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   La Paz, Bolivia
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   Mr. Richard J. Peters
   Mr. J. Isaac Torrico
   Ms. Liliana Michal

2. Divison of Economic Studies, Department of Marketing
   Ministry of Agriculture
   Av. Camacho
   La Paz, Bolivia

   Ing. Fredy Artega H.

3. FENCA, La Paz

   Mr. Agromont
   Mr. Villa Lobos

4. Bauco Agricola de Bolivia
   Santa Cruz, Bolivia

   Mr. Guillermo Tineo, presidente (La Paz)
   Ing. Jaime Monroy, gerente general (La Paz)
   Mr. Emilio Ecos
   Mr. Guillermo Vargas
   Mr. Nicholas Aldana
   Ing. Abton Quintonilla F.

5. FENCA (Federacion Nacional de Cooperativas Arroceras)
   (National Federation of Rice Growers Coops)
   Sara 179
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   Unfortunately, other names were not obtained.

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Lic. Oriel Rojas

7. CIAT (Centro de Investigacion Agricola Tropical)
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Ing. Carlos Vaca Diez B.

8. CAO (Camara Agropecuaria del Oriente)
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Eng. Richard E. Bacha

2. CFP (Comissao de Financiamento da Producao)
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Ms. Lizite Rihan Cypel

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3. Associacion Nacional de Molineros de Arroz
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Mr. Marcos Fernandez G.

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Dr. Frank H. Baker, Oklahoma State U.
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Dr. Roger G. Hanson, U. of Missouri

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5. ENPROVIT (Empresa Nacional de Products Vitales)
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6. ENAC (Empresa Nacional de Almacenamiento y
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7. National Rice Program
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Mr. Edward C. Bursey

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Mr. Nigel J. B. Holmes

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2. USAID
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Mr. John Withers
Mr. Fletcher Riggs
Mr. M. A. Nair

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6. Modern Rice Mill, Food Corporation of India
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7. Thanjore Coop Marketing Federation, oil extraction mill
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   Mr. S. Krishnamurthy, Government Agent and Acting Manager

8. Jadavpur University

9. Punjab Agricultural University
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    Mr. M. Kuppuswamy

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    P. K. Ramanathan
    Mr. H. Krishna Murty
    Mr. S. K. Majumder
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R. K. Mukherjee, Rice Technologist
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H. Das
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13. Central Fuel Research Institute
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14. Food Corporation of India

15. C.M.E.R.I.
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16. Agricultural Engineering Institute
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3. ESCAP (U. N. Economic and Social Commission for Asia and the Pacific)
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4. CRIA - Central Research Institute of Agriculture
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Ir. Soemardi
Ir. Slamet Zubaidy

5. MIDC - Metal Industries Development Center at Bandung is supported by UNDP-FAO-UNIDO but main support comes from Belgian government.

6. Fak. Technologi Pertanian
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7. BULOG (National Logistics Agency)
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Mr. J. A. Farlane, Biologist (TPI, Team Leader)
Mr. A. D. Gracey, Storage Engineer (TPI)
Mr. M. T. Locke, Training Specialist (TPI)

9. Department of Agriculture (ROI)
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BamGang Gunarto

10. Department of Agriculture
Directorate of Production
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11. Direktorat Jendral
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Mr. B. P. K. Soemartono (Indonesian representative to ASEAN, on food products)

12. U. S. Embassy
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Mr. Hammer, USAID

ITALY

1. FAO
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16. Aoki Mfg. Co., Ltd.
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17. Iony Co., Ltd.
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2. Embassy of the United States
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   Mr. Gordon S. Nicks, Agricultural Attache

3. Ministry of Agriculuture and Fisheries
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   Peon Si, Sam Seong Jong Mill

   Mr. Cho Chan Heng (Mr. Cho)

7. Kyeong Gi Do - Yong In Gun - Ki Hung Myeon
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LIBERIA

1. USAID, Monrovia

   Mr. John M. Cornelieus, Chief, Agricultural Division

2. WARDA (West Africa Rice Development Association
   Monrovia

   Dr. Dunstan Spencer, Economist
   Dr. Fugadori, Rice Specialist, visiting from Japan
   Dr. D. D. de Boer, FAO Consultant

3. Ministry of Agriculture, Monrovia

Mr. Alfred Tubman, Asst. Minister for Technical Services
Mr. Lennard Bailey, Technical Coordinator, Min. of Agriculture
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2. USAID
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3. Ministerio de Agricultura y Alimentacion
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Ing. Jose Mendez, Rice Specialist

4. EPSA (Empresa Publica de Servicios Agropecuarios)
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   Dr. Ben Juliano, Food Technologist
   Dr. Vega, Assistant Director
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2. University of the Philippines - Los Banos (UPLB)
   Institute of Agricultural Engineering and Technology (INSAET)
   Los Banos - Laguna

   E. P. Iziala, Head
   Dr. Ernesto Lozada, Assistant Professor
   Dr. Emerico Mendoza, Assistant Professor
   Ing. Pablo Hidalgo
   Ing. Ruben E. Monalabe
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3. University of the Philippines
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4. Embassy of the United States
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Mr. Glenn R. Samson, Agr. Attache

5. USAID - Philippines

Mr. Keith Sherper, Deputy Assistant Director

6. National Grains Authority
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Mr. Pablo V. Pablo, Jr., Deputy Adm. (97-72-89)
Mr. Galo Garchitorena, (Corporate Planning) (62-51-19)
Mr. Francisco Tua, Director, Tech. Services (99-45-71)
Mr. Max Ramos, Mech. Engr. (62-23-57)
Mr. Romeo L. Engracia, Supvng. Officer
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7. Asian Development Bank
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Mr. Teddy Wickenerame

8. SEARCA (See special section)
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10. Development Bank of the Philippines
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11. Marinas Machinery Co., Inc.
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12. Philippine Rural Reconstruction Movement
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Mr. N. N. Queral
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13. Department of Agriculture
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1. USAID, Freetown

Mr. Norman Sheldon, Agricultural Economist

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Emlyn Jones, Head, WARDA Mangrove Swamprice Project
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1. Rice Processing Development Center
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Mr. J. Ramalingam, Project Manager
Dr. Rama Rao V. Vellanki, Process Specialist
Mr. Moonasinghe, New Director

2. Department of Agriculture

Mr. D. H. J. Abeyagoonasekera, Deputy Secretary of Agriculture
Mr. A. Bandaranayake, Director of Agriculture

3. Paddy Marketing Board
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Mr. R. B. Alawattegama, Chairman
Mr. Lakshman Velupillai, M.E.

4. Anuradhapura District Millers Association

   Mr. Stanley Wyelingan (?), President

5. M/S Somasiri Huller Manufactory
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   Mr. M. D. P. Dias

6. M/S Dheerasekera Motor Works
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7. USAID-IRRI-FF
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5. Chi-Chi Farmers Association (Mill)

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6. Tsao Ton Farmers Association (Modernized Mill)

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7. Mao Li County Farmers Association (?)

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2. Kasetsart University
   Bangken, Bangkok

   Mr. Sermsak Awakul (Rice Division)
   Mr. Suwit Bunyawanchkul (Rice Division)
   Mr. Maitre Thongswang (Engineering Division)
   Mr. Salon Pengtovongsa (Engineering Division)
   Mr. Larb Rubsiri (Mech. Eng.)
   Mr. Salon Pengtovongsan (Eng.)
   Mr. Kumnuan Tunpun (Eng.)
   Mr. Nakhon Bunyaphlanan (Eng.)

3. USAID
   (address unknown)
   Bangkok

   Mr. Thomas L. Cooper
   Mr. Flemming
   Dr. Robert Ralston (not visited)

4. J. Chaidee Shop
   217 Mahachaukapeu Road
   Chachengsao

5. Asian Institute of Technology
P.O. Box 2754 — Tel: 5168311-5
Bangkok

Mr. Robert B. Banks
Mr. Gajendra Singh
Dr. R. H. B. Exell
Mr. V. K. Jindal
Dr. Mayhum

6. Rockefeller Foundation
GPO Box 2453 — Tel: 579-0577, 579-4858
Bangkok — Cable: Rockfound

Mr. Fred E. Nichols

7. International Finance Corporation
World Bank Group
Central Bank of the Philippines
Manila, Philippines

Bing Shen (met in Bangkok at Kamchai)

8. ESCAP (Economic and Social Commission for Asia and Pacific)
UNIDO (United Nations Industrial Development Organization)
U. N. Building, Bangkok — Tel: 2829161
Cable: ESCAP

Dr. H. G. R. Reddy

9. MBI, Ltd.
197/1 Silom Road — Tel: 2332156
Bangkok

Mr. S. Kosol

10. FAO Regional Office
Maliwan Mansion — Tel: 281-7844
Phra Atit Road — Cable: foodagri, Bangkok
Bangkok

Dr. D. L. Umali, Asst. Director General
Dr. H. G. R. Reddy
U Thet Zin, Regional Agr. Officer
Mr. B. N. De los Reyes, Program Officer
U Maung Maung, Rice Milling Officer

11. Division of Agricultural Cooperatives

Thavi Nicrothananda
Pragob Phukumachai
Sa-art Kaewkes

12. Heng Thye Rice Mill
168 Nakornluang
Ayudhya

Inga Sriprasert
Viboon Sriprasert

13. District Coop Office
Don Chedi District
Suphan Buri Provence

Anek
Sawan
Subin

VII. REFERENCES

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2. Harper, A. E. and Hegsted, D. M. Improvement of Protein Nutritive. National Academy of Sciences, Washington, D. C. 1974.

3. FAO bulletin W/L2783. FAO Action Program for the Prevention of Food Losses Guidelines and Procedures. Rome, January 1978.

4. National Academy of Sciences, "Postharvest Food Losses in Developing Countries, NAS, Washington, D. C. 1978.

5. FAO bulletin FERC/78/6. Promotion of Food Security with Special Emphasis on Reduction of Postharvest Food Losses. Rome, May 1978.

6. Agricultural Statistics, 1976. United States Department of Agriculture.

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13. Askin, P. W. Intermediate Technology: An Informal Survey. 18th Session, Senior Seminar in Foreign Policy. Department of State, 1976.

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17. Toquero, Z., Maranan, C., Ebron, L., and Duff, B. Assessing Quantitative and Qualitative Losses in Rice Post-Production Systems. FAO Workshop on Postharvest Rice Losses. Malaysia, March 1977.

18. Joint Commission on Rural Reconstruction. Taiwan Agricultural Machinery Guide, 1978. JCRR, Taipei, Taiwan.

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20. Van Ruiten, H. In: Rice Postharvest Technology, E. V. Araullo, D. B. de Padua and M. Graham, Eds., IDRC, Ottawa, Canada (p. 217).

See Part 2 for a more complete bibliography of over 300 references on rice postharvest losses in developing countries.

Country	Contacts	Equipment
BRAZIL		
Industria Machina D'Andrea, SA Caixa Postal 55 Avenida Souza Kueiros 267 13,480 LIMERA, S.P. Tel: 1277 or 1892 Cable: DEANDREA LIMEIRA, S.P., Brazil		Threshers, cleaners, driers, mills, etc., including small sizes.
Industrias Machina Zaccaria, SA Caixa Postal 54 Rua Laranjal 180 or Largo da Boa Morte #11 CEP. 13,480 LIMEIRA, S.P., Brazil Tel: 1202 or 4202, Telex: 019-1151		Driers and (?) mills.
Kepler, Weber, SA Caixa Postal 2 Rua Herrmann Meyer 43 98,280 PANAMBI, R.S. Tel: 2 and 32, Cable: KEPLERSA and offices also at: Av. Otavio Rocha 115 90,000 PORTO ALEGRE, R.S., Brazil Tel: 25-1619 or 25-2094		Driers and cleaners.
Lucato Mills Melchers, Prestefelippe and Cia, Ltd. (probably sales agents) Av. Julio de Castilhos 84 PORTO ALEGRE, R.S., Brazil Tel: 24-7695 or 25-3439		Mills and (?) driers.
Mernak, S.A. Rua Otto Mernak 276 - Caixa Postal 23 Cachoeira Do Sul RIO GRANDE DO SUL, Brazil	Mr. Eloi	Builds two series of Lokomoveis (Lokomobile) similar to Buckau R. Wolf or Esterer engine.
Suzuki (address unknown)		Lab mills and other equipment.

COLOMBIA

Compania de Inversiones El Condor, Ltd. Carrera 30 Barrio Morales TULUA, Valle, Colombia Tel: 2553 or 4677	Mr. Marcus Fernandez, President Mr. Eduardo Marin, Chief Engineer	Driers and mills.
EMC (Empresa Metalurgica Colombiana) Plant BOGOTA, Columbia Subsidiary of AeroGlide Corp. P.O. Box 1839 Raleigh, NC 27602 USA		Rice milling machinery. Mechanical driers.
SB Industrial y Comercial, Ltd. Carrera 40 B No. 9-27/31 Apartado Aereo 10393 BOGATA, Colombia Tel: 47-13-09 Calle: BRIDGER		Drier blowers and heaters.

DENMARK

Argus Fyr A/S Femagervej 39 2650 HVISOVRE, Denmark	Mr. S. E. Perning	Manufacturer of power stokers for rice husk as a fuel.

FEDERAL REPUBLIC OF GERMANY

A. Lambion Maschinenfabrik 03548 WETTERBURG (Arolsen) Federal Republic of Germany	Mr. Alfred Lambion	Furnaces, grates, boilers. Experience in furnaces for rice husk burning.
Amandus Kahl Nachf. Hamburg Postfach 260343 Diesel Strasse 5-9 2057 Reinbek (HAMBURG) Federal Republic of Germany	Mr. Joachim Behrmann	Manufacturer of pelleting machinery.
Buhler-MIAG GmbH D33 BRAUNSCHWEIG Postfach 3369 Federal Republic of Germany	Mr. Karl-Heinz Kunde Mr. M. Wehmann	Rice milling machinery. Constructor-husk fired. Power plant builder.
Eisenwerk Theodor Loos GmbH 3820 GUNZENHAUSEN Nurnberger Strasse 71-75 Federal Republic of Germany	Ing. H. Ernst	Boiler manufacturer.

Naumann & Co. 02000 HAMBURG 74 Berzeliusstrasse 7-11 Federal Republic of Germany		Hanseata rice mills and rice machinery. Husk fired driers.
Cornelius Schmidt Eisen Und Stahlwerk Von Kettelen Strasse 1 609 LEVERKUSEN, Kuppersteg Federal Republic of Germany	Mr. Simon Mr. Paland	Manufacturer of rice husk burning furnaces and grates. Dedusting and scrubbing equipment.
M/s F. H. Schule GmbH Maschinenfabrik Postfach 260 620 D-2000 HAMBURG 26 Federal Republic of Germany	Mr. Hans G. W. Keesenberg Mr. H. Petersen Mr. R. Runte	Rice milling machinery, complete rice mills, complex, driers, parboil and steam power plants.
Siller & Jamart KG 66 WUPPERTAL-Barmen Horather Str. 20-24 Federal Republic of Germany		Husk fired boilers.
Spillingwerk HAMBURG GmbH 2000 HAMBURG 11 Postfach 11 05 29 Federal Republic of Germany	Mr. H. Spilling	Steam motor manufacturers. Complete husk fired power plants. Contractors.
Streckel & Schrader KG 2 HAMBURG 70 Hinschenfelder Str. 35 (Postfach 70 15 47) Federal Republic of Germany	Dipl. Ing. Karl Streckel	Rice milling equipment manufacturers. Complete rice mills.

GERMAN DEMOCRATIC REPUBLIC

M/s. Transport Maschinen, Deutscher Inner & Ausenhandel 108 BERLIN-108, John Dieckmann Strasse 11-13, German Democratic Republic		
VEB Maschinen und Muhlenbau Wittenberg Betrieb des VEB Lutherstadt Fortschnitt 46 WITTENBERG, Lutherstadt German Democratic Republic	Mr. Hans Georg Kaiser	Rice milling machinery manufacturer.

GHANA

Attah Farm Equipment Supplies P.O. Box 100 AKOSOMBO, Ghana		Axial flow, thresher, batch drier.

INDIA

American Spring & Pressing Works Ltd. P.O. Box 7602 Marve Road, Malad BOMBAY 400-064, India		
Behere's Industrial Works Rice Milling & Corn Polishing Machinery Manufacturers Dhanu Road, Western Railway Dist. Thana (MAHARASHTRA) India		Rice mill machinery, disc sheller.
Bharat Industrial Corporation Petit Compound Grant Road, BOMBAY-7 India		
Binny Limited P.O. Box 1111 Meenambakkam MADRAS 600 061, India	Mr. M. R. Gopal	
Chatta Engineers Enterprises Fabricators of Rice Mills Outside Chatwind Gate, AMRITSAR (Punjab), India		
Chemech Engineers Private Ltd. 1613, Sterling Road Nungambakkam (MADRAS) 60034, India		Driers, parboiling, construction.
Chemical Engineers Corp. Kalkaji Temple NEW DELHI, India		Rice bran oil extraction plants.
Damodar Enterprises Ltd. 1-A, Vansittart Road CALCUTTA-1, India		Rice milling equipment manufacturer.
G. G. Dandekar Machine Works Ltd. Dandekarwadi BHIWANDI 1-421 302 (Thana) India	Mr. A. K. Goil	Rice milling machinery, rice mills, minimills - 250 Kg.
DeSmet (India) Pvt., Ltd. Shree Niketan, Block F Worli, BOMBAY-18, India		Oil extraction plants for rice bran.

Francis D'Souza & Co. Dhanu Road, Western Railway Dist. Thana (MAHARASHTRA) India		Rice mill machinery, disc sheller.
Engineering Services Corp. No. 2, R.S.V. Naidu St. Kilpauk, MADRAS-10, India	Mr. D. J. K. Cornelius	Developing hot air generator fired by husk. husk. Rice milling handling equipment constructor-designer.
EskayJay 399 Jadhpur Park CALCUTTA 31, India		Parboil plants, driers, mechanical handling.
Essential Engineering Co. 11/13, Botalwala Building Horiman Circle, Fort BOMBAY-1, India		
Geekay Engineering Industries, Kashmiri Road BATALA (Punjab), India		
M/s. General Engineering Works Udipi (BANGALORE), India		
B. D. Ghodke & Sons Ayodhya Rd., Old Hubli Dist. Dharwar (MYSORE), India		Rice mill machinery, disc sheller.
Grain Storage & Processing Ind. 29 Strand Road CALCUTTA-1, India		
Greaves Cotton & Co. Ltd. 1 Dr. V.B. Gandhi Marg P-B No. 91 BOMBAY 400 023, India	Mr. I. P. Gopal-Ram Mr. R. V. Natu Mr. I. K. Kumar	Sole concessionaire. Westerworks boilers, gas.
Guru Charan Industrial Works, Station Road. MAINPURI, U.P., India		
Hindustan Industrial Corp. (Agro-Industrial Division) K-40, Connaught Circus NEW DELHI-1, India		Parboil.
Indian Foundry Works Border Road FEROZEPUR CITY (Punjab), India		

Industrial Sales & Services 11 Clive Row, 9th Floor CALCUTTA 700001, India Tel: 021-2536	Mr. V. S. Aggarwal Mr. Shrish Aggarwal	Pressure parboiling, mechanical drying plants and equipment.
Jaya and Company Boiler Engineers P.O. Box No. 1347, Trichy Rd. COIMBATORE-641018, India	Mr. J. S. Kamath, Partner	Husk fired boilers.
Karshak Industries 18-3-14 Boiguda LALDARWAZA Hyderabad 500 002, India		
Kirloskar Oil Engines Ltd. Corporate Office 11, Koregaon Road POONA-411 001, India	Mr. S. K. Joshi	Rice milling equipment (Schule, Dandekar) - gas, oil and diesel engines.
Kisan Krishi Yantra Udyog 64 Moti Bhawan, Collectorganj, KANPUR 208001, India	Mr. P. L. Toshniwal	Minimill (CFTRI).
Kuljian Corporation India (Pvt) Ltd. 24B, Park Street CALCUTTA-16, India		Parboil plants, driers.
Meerraja Engineering Works VZIANAGARAM-531201 (Andra Pradesh), India		
Modern Machineries Corp. 11 Clive Row CALCUTTA-1, India	Mr. Shrish Aggarwal	Rice mills, rice milling machinery. Concessionaire - Dandekar, parboil plants.
Qualitex Machinery Pvt. Ltd. 64, Industrial cum-Housing Estate Mile Stone 21, Mathura Road FARIDABAD (Haryana), India		Minimill.
Rajalakshmi Industries 17, Vijaya Park, Navrangapura AHMEDABAD-9 (Gujarat), India		Minimill.
Rajan Trading Co. P.O. Box 250 MADRAS 600 001, India		

Rekha Industries Bl-A.P. Industrial Estates TENALI-522 202, (A.P.), India	Mr. J. S. R. Setty	Rubber roll shellers, rice mill machinery. Rubber roll huskers.
Servotech Engineers Pvt. Ltd. B-21/27 "Commerce Center" Tardeo, BOMBAY-400 034 India	Mr. P. P. Sarma	Manufacturer of rice bran oil plants.
Shaw Wallace & Co., Ltd. 7, Linghi Chetty St.-P.B. 14 MADRAS-1, India	Mr. L. R. Sharma, Div. Mgr.	Manufacturer of husk fired dryers and parboiling equipment.
Troika Processes Pvt. Ltd. 607 Embassy Centre Nariman Point BOMBAY-400 021, India	Mr. R. S. Jhaveri Mr. P. G. Bhandari	Manufacturers of rice bran oil plants.
Union Tractor Workshop 8b Phase II Mayapuri Industrial Area NEW DELHI 110 027, India		IRRI thresher.
Wanson, India (P), Ltd. CHINCHAWAD (Poona) 19, India		Supplier to Dandekar of boilers.
Westerwork Engineers Pvt. Ltd. 5-D Vulean Insurance Bldg. Veer Nariman Rd., Churchgate BOMBAY 400 020, India		Husk fired boilers and furnaces (sole concessionaire, Greaves Cotton & Co. Ltd.).

INDONESIA

Buma Sakti - Bandung		
IKABI Primkopad Bengpusmat II Divisi Produksi Mesin dan Engineering P.O. Box 299 BANDUNG, Indonesia		
Indra SURABAYA, Indonesia		Rubber roll sheaths.
PINDAD (Perindustrian Angkatan Darat) P.O. Box 8 BANDUNG, Indonesia		
P.T. Purna Sadhana P.O. Box 192 JAKARTA, Indonesia		

C. V. Karya Hidup Sentosa Jen. Magelang 144/150 YOGYAKARTA, Indonesia	Kirjohadisoseno	Threshers.
Pabriek Mesin/Bengkel Besi "LAM TJIN" Djalan Raja Tjinangoh 261 KRAWANG-DJABAR, Indonesia		Milling equipment, small puffing gun.

ITALY

Baldeschi & Sandreani Lungotevere Flaminio 22 00196 ROME, Italy		
Colombini & C. snc via Cadorna 9 20081 ABBIATEGRASSO (Milan), Italy		
Gariboldi S.A.S. Via Pienza 20 20142 MILAN, Italy	Franco Gariboldi	Rice mill machinery.
Gariboldi S.N.C. Via Bertarini 72 20061 CARUGATE (Milan), Italy		Manufacture of husk fired steam plants parboiling plants, boilers, furnaces.
Minghetti VERCELLI, Italy		Rice mill machinery.
Olmia VERCELLI, Italy		Rice mill machinery.

JAPAN

Aoki Mfg. Co., Ltd. 26-5, 2-chome, Taito Taito-ku TOKYO, Japan		Whiteners.
Boso Oil & Fat Co. Ltd. 1-1, Nihonbashinhon-cho Chuo-ku, TOKYO, Japan	Mr. S. Oyamada, President Mr. Y. Joko, Manager	Rice bran oil extraction plants.
Chiyoda Chemical Engr. & Construction Co. Ltd. 1580, Tsurumi-cho, Tsurumi-ku YOKOHAMA CITY, Kanagawa-bu, Japan		

Chuo Boeki Goshi Kaisha (Central Commercial Co.) (CeCoCo) P.O. Box 8, IBARAKI CITY, Osaka fu, Japan	Mr. Y. Kagawa, Managing Director	Builders and sellers of carbonizers, husk fired driers, husk fired furnace. Sellers of small threshers and milling machines including some hand powered ones.
Hayashida Kikaikogyo Co. Ltd. 449, Sugimoto-cho Fushimi-ku, KYOTO CITY Kyoto-fu, Japan		
Iony Co., Ltd. 2-16, 6-chome, Shinkawa Mitaka-shi TOKYO, Japan	Mr. T. Masumoto, Managing Director	Rice milling machinery.
Iseki Agricultural Machy. Mfg. Co., Ltd. 2-2, Nihonbashi-dori, Chuo-ku TOKYO, Japan		Rice milling machinery, paddy separator, butterfly type, rubber roll husker, driers.
Kaneko Agricultural Machinery Co., Ltd. 21-10 Nishi 2-chome HANYU CITY, Saitama-348, Japan	Mr. Aijiro Kaneko, President Mr. Tadahiro Higuchi, Chief Mr. Yoshiyuki Saito, Manager Mr. T. Watanabe, Director	Builders of husk fired driers. Gasification, combustion, carbonization and heat supply equipment. Continuous drier, ventilation drier, circulating drier.
Kansai Sangyo Co., Ltd. 1666 Minamikawase-cho HIKONE CITY, Shiga-522-2, Japan	Mr. Masahiro Kojima, President Ms. Toshie Kojima	Builder of carbonization equipment, incineration and gasification equipment.
Keibumsha Seisakusho Co., Ltd. 2-2-15, Kujunoki-cho HIROSHIMA CITY, Japan	S. Aoki, Director	Husk char equipment.
Kett Electric Laboratory 8-1, 1-chome Minami-Magome, Ota-ku TOKYO, Japan		Moisture meters.
Kiya Seisakusyo Co., Ltd. KAWAGOE CITY, Saitama-fu, Japan Tel: (0492) 423555		Debearder, rubber roll husker, power thresher, testing machines.

Kokusai Jako Co., Ltd. 4-1-8, Honmachi KAWAGOE CITY, Saitama-fu Japan	Mr. Khiro Kobayashi	Manufacturers of domestic stoves using rice husk as fuel.
Moori Seikoku Kenkyusho Co. Ltd. 2-8-26, Kyomachi HIKONE CITY Shiga-fu, Japan		Whiteners.
Musaski Koki Co., Ltd. Shinbashi Ekimaebiru 2-Chome, Shinbashi Minato-ku, TOKYO, Japan		Rice bran oil extraction plants.
Nichyu Koki Co., Ltd. No. 11-5, Hacchobori Chuo-ku, TOKYO, Japan	Mr. Sakai	Builders of carbonizing furnaces.
Ohtake Nouki Seisakusho Co., Ltd. Nakajimi, Ohharu-mura, Amagun AICHI, Japan		IRRI.
Ooyama Tetsukosho Co. Ltd. 4-4-29 Rokukakubashi-cho Kanagawa-ku, YOKOHAMA CITY Kanagawa-fu, Japan		
Oshima Agricultural Machinery Mfg. Co., Ltd. 10-17, 3-chome Teramachi JYOETSU CITY Niigata pref., Japan		Driers.
Sanriku Noki Co., Ltd. (address uncertain)		Centrifugal sheller.
Satake Engineering Co., Ltd. Ueno Hirokoki Bldg. Ueno 1-19-10, Taitoku, TOKYO, Japan	Mr. Yoshiharu Satake, Managing Director Mr. Hisashi Ishida, Manager Overseas Mr. Masataka Kita Mr. Konomu Matsui	Builders of rice milling machinery, driers, carbonizers, etc.
Shibuya Kogyo Co., Ltd. Daizudahan, Cho KANAZAWA CITY Ishikawa Pref., Japan		

Shinomiya Mfg. Co., Ltd. 5-8, 2-chome, Minamihon-cho JOETSU CITY Niigata pref., Japan		Rubber huller system.
Shizuoka Seiki Co., Ltd. 4-1 Yamana-cho FUKUROI CITY Shizuoka-437, Japan Tel: (05384) 2-3111		Low temperature, high air flow driers; box type driers.
Suzuki Ryoshoku Kenkyusho Co., Ltd. 2-1-19 Jiyugaoka Meguro-ku, TOKYO, Japan		Rice bran oil plants.
Tabata Yuki Co. Ltd. 2-9-8 Jujonakahara Kita-ku, TOKYO, Japan		Rice bran oil plants.
Takano Seisakusho Co. 470 Kamikumano TOYAMA, Japan		Builders of carbonizing furnace for driers, water heaters, etc.
Tanizawa Kakikogyo Co. Ltd 622, Kamitoda TODA CITY, Saitama-fu, Japan		Rice cracker.
Toyo Seimaiki Seisakusho Co. Ltd. 12, Kuroda, WAKAYAMA CITY Wakayama-fu, Japan		
Yamato Sanko Mfg., Ltd. Katakura Bldg., Kyobashi TOKYO, Japan Tel: 03-281-5301	Mr. Yukio Yamato, Technical Director	
Yamamoto Mfg. Co., Ltd. 813-17, Tendo-ku, Tendo-shi YAMAGATA-ken 994, Japan Tel: (02364) 33411		
Yanmar Diesel Engine Co., Ltd. 1-11-1 Marunouchi, Chiyoda-ku TOKYO, Japan Tel: (03) 213-8111	Mr. Yasuo Watanabe Mr. Seisuke Sakemi	Builders of rice milling machinery (Kyowa). Rice mills and machinery, mini-rice mill, mini-rice center.
Yoshino Seisakusho Co. Ltd. 6-13 Sekime, 5-chome Iyoto-ku, OSAKE 536, Japan	Mr. G. Kurata, Managing Director	Manufacturers of rice bran oil extraction plants.

KOREA

Hyup Sin Industrial Corp. 46-1 Yongdu-dong, Dongdaemun-gu SEOUL, Korea		Rice milling machinery.
Wuon Poong Co., Ltd. 21-2-ka Dang San-dong Young Dongpo-ku SEOUL, Korea		Rice milling machinery.

MALAYSIA

The East Asiatic Co., Ltd. Denmark House 84 Jalan 223 KUALA LUMPUR-04-05, Malaysia	Mr. Hans Malinowski	Rice milling, machinery; construction and design of milling and drying complexes.
Folin & Brothers SDN. BHD. Lot 16 Jalan 223 PETALING JAYA, Selangor, Malaysia	Mr. Wong Foh Ling Mr. Wong Boon Sun Mr. Teoh Geok Leong	Husk fired boilers and furnaces.
Heap Fuat & Co. PENANG, Malaysia		Rice mill machinery.
Industrial Boilers & Allied Equipment SDN. BHD. Shah Alam Works Selangor, G.P.O. Box 635 KUALA LUMPUR, Malaysia		Husk fired boilers.
Kwong Tuck Cheong Foundry & Co. PENANG, Malaysia		Rice mill machinery.

NETHERLANDS

Lindeteves-Jacoberg Export bv (was P.S. Stokvis de Zonen N.V.) P.O. Box 5014 WEEDESTEIN 17, Netherlands	Mr. J. A. Jetten Mr. J. J. Koster	New company name for old suppliers of rice milling machinery.

PAKISTAN

Habib Industries, Ltd. 4th Floor, Commerce Bank Bldg. I. I. Chungdrigar Rd., KARACHI-2, Pakistan		IRRI axial flow thresher.

PHILIPPINES

C & B Machinery Manufacturing Cruz-Na-Daan SAN RAFAEL, Bulacan, Philippines		Thresher.
Corwen, Inc. 708 Aurora Blvd. QUEZON CITY D 502, Philippines	Mr. Manfred B. Fischer	Experience in construction of husk fired power plants. Builder of rice mills.
Felson Machinery Inc. 2014 J. Luna St. Tondo MANILA, Philippines		Cleaner, winnower, thresher, cono, grinder.
Filipinas Mills Inc. 154 Gen. T. de Leon St. VALENZUELA, Bulacan, Philippines		Cleaner, winnower, drier.
G. A. Machineries Inc. 1200 EDSA, East Delos Santos Ave. QUEZON CITY, Philippines	Mr. Edilberto A. Uichanco Vice President	Winnower, cleaner, drier, thresher, cono grinder, corn corn sheller, mechanical harvester.
G. A. Machineries, Inc. (GAMI) Marulas, VALENZUELA Bulacan, Philippines		Moisture tester.
Grace Park Engineering Inc. 7th Ave. Grace Park CALOOCAN CITY, Philippines Tel. #35-43-70		Rice mill, drier.
IGRI Industrial Sales Corp. MAFT 484 Araneta Blvd. QUEZON CITY, Philippines (P.O. Box 24, MANILA)		MAFT, rice mill.
F. E. Zuellig (M) Inc. IMAG Mfg. Division 64 Kitanlad Street QUEZON CITY, Philippines (P.O. Box 604, MANILA)		
JCCE Industries 242 Mayonoon Los Banos, LLAGUNA, Philippines		

Kalayaan Engineering Co. Inc. Suite B 5th Floor Dao I Cdmn. Salcedo St., Legaspi Village, MAKATI, Metro Manila, Philippines		MAFT, thresher.
Kalayaan (Asia Pacific) Engineering Co. Inc. 4255 Emilia Street P.O. Box 665 Makati Comm. Ctr. MAKATI, Rizal, Philippines	Mr. Rafael A. Lahoz, Jr. President	Manufacture of husk fired drier, Thresher, drier.
Kaunlaran Industries, Inc. Kaunlaran Bldg., Calamba, LAGUNA, 3717, Philippines	Mr. Arsenio E. Dungo, President	Manufacture of husk fired drier.
Marsteel Corporation ACB Building, 666 T. M. Kalaw, MANILA, Philippines (P.O. Box 834, MANILA)		Drier. MAFI/thresher.
Marvex Commercial Co., Inc. 153-13th St. cor. Chicago, Port Area, Mla. MANILA, Philippines		Locally made rubber rolls by Marvex Co. Drier, thresher.
Mechanical Factors Phil. Inc. 380 Shaw Blvd., Greenfield Bldg. 2 MANILA, Philippines		Moisture meter, drier, thresher, roller.
Mechanical Factors Phil. Inc. 380 Shaw Blvd. Mandaluyong, RIZAL, Philippines		
Oberly & Co., Inc. 253 Mayon St., Sta Mesa Heights QUEZON CITY, Philippines		Winnower, cleaner, thresher.
Parpana Machinery Mfg., Inc. 1440 A. Rivera St. Tondo, MANILA, Philippines		Rice mill, thresher, Kiskisan corn sheller, decorticator corn grinder.
Philip Engrg. & Steel Industries ADCOM, Philippines 811 Sikatuna Bldg., Ayala Ave. Makati, RIZAL, Philippines		Power paddy cleaner, box drier, multicrop axial flow thresher.
A. P. Rodriquez Agro-Industrial Machineries Bitas, CABANATUAN CITY, Philippines Tel: 33-04		Box drier.

Warner Barnes & Co., Inc. 2900 Faraday cor. South Expressway Makati, Metro MANILA, Philippines		Kiskisan, grinder, corn sheller, weighing scale, thresher.

SPAIN

Juan Torrejon Visitacion 18 VALENCIA, Spain		
Talleres Genevois Grao-Valencia Islas Canarias, 170 VALENCIA-11, Spain		Builders of furnaces, boilers.
Imad S. A. Camino de Moncada, 83 Apartado 21 VALENCIA-9, Spain		Manufacturers of rice milling machinery.

SRI LANKA

Associated Rubber Industries 185 Union Place COLOMBO, Sri Lanka		
Brown Group Industries, Ltd. 481 Darley Road COLOMBO, Sri Lanka		
Dheerasekera Motor Works Abeygunerathna Mawatho Pamburana, MATARA, Sri Lanka	Mr. W. Dheerasekera	Complete rice mills, VS-VP paddy separators, paddy cleaners, rubber roll huskers, whitening-cones. Vertical cone polishers.
M/s. A. Dheerasekera Industries 106 Rahula Road MATARA, Sri Lanka		Paddy separator, rubber roll sheller.
M/s. Gunapala Industries, MATARA, Sri Lanka		
M/s. Nugaduwa Ceylon Engineering Corporation Ltd. KATUGODA (Galle), Sri Lanka		Vert. cone, whiteners.
M/s. Rakheeb Industries, 112 Kotuwegoda, MATARA, Sri Lanka		Paddy separators, whitening cones, rubber roll, huskers, paddy separators.

M/s. Samuel Sons & Co. Ltd. 371 Old Moor St. (P.O. Box 46) COLOMBO, Sri Lanka		Driers, elevators.
M/s. Somasiri Huller Manufactory 18, Parakrama Ave., Kohuwela NUGEGODA (Colombo), Sri Lanka Tel: 073-2258	Mr. M. D. P. Dias	Complete rice mills, rubber roll huskers, paddy cleaners, whitening cones.

SWITZERLAND

Bernhard Keller AG Hardstrasse 235 8005 ZURICH, Switzerland		
Spilling Consult. Ag. Sonnenweg 4 CH-5610 WOHLEN, Switzerland	Dipl. Heinz Spilling	Power plant and utility consultants, has built sophisticated rice husk burning power plant.

TAIWAN

China Agricultural Machinery Co., Ltd. 4th Floor, Tun Hwa Buldg. TAIPEI, Taiwan		Drier.
Chen San Fung Machinery Industrial Co., Ltd. 715 Shui Yuan Road FUNG YUAN, Taichung District, Taiwan Tel: (045) 225108-9 and No.8, 9-Lane, 1 Sec. Chumg Ching North Road TAIPEI, Taiwan Tel: (02) 5417068	Mr. Pi Chung Yu, President	Hullers and polishers.
Hei-cheng Agricultural Machinery Co., Ltd. 196 Wei Kun Road MEU-Li, Taiwan	Mr. J. C. Lin	Dehullers.
Kuo Hua Agric. Engine Works Co. 1, Lane 104, Chung Hsiao Rd. TAICHUNG, Taiwan		Box drier.

Sun Jeu Industrial Machinery Co., Ltd. 1059 Chung Jen Road FUNG YUAN, Taichung District, Taiwan	Mr. H. W. Hsu	Driers.
Taichun Rubber Factory Co. Ltd. 35, Lane 162, Tsen Sin Road TAICHUNG, Taiwan		Rubber roll tires.
Young Eagle Enterprise Co., Ltd. (P.O. Box 198 Keelung, Taiwan) No. 60 AI San Road KEELUNG, Taiwan Tel: 22325		Threshers (Shieh-Tsen Brand).

THAILAND

Amorn Chai Co., Ltd. (Kamol Kij Co., Ltd.) 295/26 Suriwong Road BANGKOK, Thailand	Mr. Kamchai Iamsuri	
Anusarn Co., Ltd. 94-120 Charoen Rd. CHIANGMAI, Thailand		IRRI axial flow thresher.
S. Yout Chai L.P. (address unknown) Thailand		Rubber roll husker.
Chaiwat Panich Shop 1 Moo 12 Tambol Neungkeat Amphur Muang, CHACHOENGSAO, Thailand	Mr. Takulchai Chaiwat	Axial flow thresher.
J. Chaidee Panich 217 Mahajakkapat Road Amphur Muang, CHACHOENGSAO, Thailand	Mr. Rong Srichan	Axial flow thresher.
Huay Nam Boiler Factory 164 Ma Kua Lane, Wat Phya Krai Yannava District BANGKOK 12, Thailand	Mr. Kitti Thiranonda	Husk fired. Boiler manufacture (Cornish type).
The Jakpetch Tractor Co., Ltd. 14 Moo 3 Soi Onnuj Km. 20 Lad Krabang, BANGKOK, Thailand		

Kwang Thai Seng Factory 216 Talad Lwang, Bang-rak BANGKOK, Thailand	Ms. Khun Pornphun Viri Yayonthr	Builder of steam engines. Complete rice mills.
Lee Yung Cheing Factory Opposite of Wat Pratum, Talad Noi BANGKOK, Thailand		Builder of steam engines and boilers. Complete rice mills.
The MBI Co. Ltd. 7th Floor Silom Building 197/1 Silom Road BANGKOK-5, Thailand	Mr. S. Kosol, Managing Director Mr. Kosol Singjanusong	Batch drier.
Nakornsawan Tractor Co. Ltd. 1302 Paholyothin Road, Amphur Muang NAKORN SAWAN, Thailand	Mr. Montree Sakol-Bunjerd	Axial flow thresher.
Pramual Kolakij Ltd. Part. 53 Soi Nukulthon BANGKHEN, Bangkok, Thailand	Mr. Anusorn Boon-it	Axial flow thresher.
Sathorn Works Co. Ltd. 124/10 Soi Rewadi, Tiwanond Road NONDTHABURI, Thailand	Mr. Bamrung Sathorn	Steam heat exchanger driers, rice milling machinery pellet mills. Rice mill machinery.
Sing Thai Machinery Ltd., Part. 402 Mahachak Road BANGKOK, Thailand		
Thai Seng Yont Ltd. Part. 78/10-11 Talad Taprachan, Maharaj Road BANGKOK, Thailand	Mr. Suwit Pisarnko-skul	Axial flow thresher.
Thanya Engineering 549 Moo 3, Amphur Sri Prachan SUPHAN BURI, Thailand		Axial flow thresher.

UNITED KINGDOM

Allmet (Agricultural) Ltd.
Ford House
Richardshaw Road
Pudsey LS28 6RZ
YORKSHIRE, UK

Barclay Ross & Hutchison Ltd.
67 Green
ABERDEEN AB 9 8AL, UK

E. H. Bentall & Co. Ltd.
MALDON CM9 7NW, Essex, UK

The Alvan Blanch Development
Co. Ltd.
Chelworth
MALMESBURY SN16 9SG, Wilts, UK

William Boulton Ltd.
Providence Engineering Works
Burslem
STOKE-ON-TRENT ST6 3BQ, UK

Buhler-Miag (England) Ltd
The Wood House
Games Road
Cockfosters
BARNET EN4 9HL, Hertx, UK

Colman International
Colman House, Sudbury
SUFFOLK CO10 6TP, UK

John Gordon & Co.
(Engineers) Ltd.
196A High Street
EPPING CM16 4AQ, Essex, UK

Lewis C. Grant Ltd. East Quality Street DYSART, Kirkcaldy, Fife UK	Mr. R. M. Storie	Manufacturers of rice milling machinery, grain, driers.

Gunson's Sortex Ltd.
Fairfield Road
LONDON E3 2QQ, UK

Kipp Kelly (London) Ltd.
729 Old Kent Road
LONDON SE15 1JN, UK

R. A. Lister Farm Equipment Ltd
Dursley
GLOUCESTERSHIRE GL11 4HS, UK

Innes Walker (Eng) Co Ltd.
Clyde Works
Brown Street
PAISLEY PA1 2SB, Renfrewshire, UK

John Wilder (Engineering) Ltd.
Hithercroft Works
WALLINGFORD, OX 109AR, Oxon, UK

USA

Aeroglide Corp. RALEIGH, North Carolina, USA	Drier.
Barnard & Leas CEDAR RAPIDS, Iowa 52406 USA	Trumbles - manlifts.
The Bauer Brothers Co. SPRINGFIELD, Ohio, USA	Attrition mill.
Berico Industries Box 12285 OVERLAND PARK, Kansas 66212 USA	Rice driers and handling machinery.
Buhler MIAG P.O. Box 9497 MINNEAPOLIS, Minnesota 55440 USA	
Burrows Equipment Co. 1316 Sherman Avenue EVANSTON, Illinois 60204 USA	Instruments, moisture meters, conveyers - elevators.
Butler Manufacturing Co. 7400 East 13th Street KANSAS CITY, Missouri 64126 USA	
CEA Carter - Day 560-73rd Ave. NE MINNEAPOLIS, Minnesota 55432 USA	Separators - screens, air pollution equipment.
Champion Products Inc. 7875 Fuller Road EDEN PRARIE, Minnesota 55344 USA	Grinders.
Chief Industries Inc. P.O. Box 2078-Dept. XB GRAND ISLAND, Nebraska 68801 USA	Storage tanks.

Chromalloy P.O. Box 431 1460 Auto Avenue BUCYRUS, Ohio 44820 USA	
Clayton & Lambert Mfg. Co. BUCKNER, Kentucky 40010 USA	Rice driers (farm type).
Crippen Manufacturing Co., Inc. ALMA, Michigan USA	Scalpers and cleaners.
Delux Mfg. Co. Box Q KEARNEY, Nebraska 68847 USA	Driers - 500/3000 Bu/hr.
Dickey-John P.O. Box 10 AUBURN, Illinois 62615 USA	Moisture meters.
The Duplex Mill Mfg. Co. (Kelly-Duplex) Cor. Sigler and W. Pleasant Sts. SPRINGFIELD, Ohio 45501 USA	All types of mill equipment.
Farm Fans Inc. 5900 Elmwood Avenue INDIANAPOLIS, Indiana 46203 USA	Driers.
Ferrell Ross 1621 Wheeler Street SAGINAW, Michigan 48602 USA	Drier.
Dave Fischbein Company P.O. Box 6025 MINNEAPOLIS, Minnesota 55406 USA	Bag closers.
Forsbergs, Inc. P.O. Box 510 THIEF RIVER FALLS, Minnesota 56701 USA	Gravity tables, graders.

Fort Worth Steel & Machinery Co. 3600 McCart Street P.O. Box 1038 FORT WORTH, Texas 76101 USA		Screw conveyors, drivers.
Holz Rubber Company 1129 S. Sacramento Street LODI, California 95240 USA		Polyurethane husker tires.
S. Howes Co. 1957 Miller Street SILVER CREEK, New York 14136 USA		Eureka cleaners, aspirators.
Huntley Manufacturing Co. BROCTON, New York 14716 USA		Monitor cleaners, paddy separators.
International Harvester Co. 401 North Michigan Avenue CHICAGO, Illinois 60601 USA		
Jacobson Machine Works Inc. 2453 Nevada Avenue North MINNEAPOLIS, Minnesota 55427 USA		Grinders.
Ludlow-Saylor Inc. 634 S. Newstead Avenue ST. LOUIS, Missouri 63110 USA		Wire cloth screens.
McBurney Stoker & Equipment Co., Inc. P.O. Drawer 47848 ATLANTA, Georgia 30340 USA	Mr. W. B. McBurney	Stokers and husk fired power plants.
McGill (H.T. McGill & Co. is no longer in Texas) c/o Mercator Corporation P.O. Box 142 607 Washington Street READING, Pennsylvania 19603 USA		Laboratory equipment.
Motomco, Inc. 89 Terminal Avenue CLARK, New Jersey 07066 USA		Moisture meters.

Oliver Manufacturing Co., Inc. ROCKY FORD, Colorado 81067 USA	Specific gravity tables.
Pacific Polymers PORTLAND, Oregon USA	Polyurethane husker sheaths.
Schutte Pulverizer Co., Inc. 65 Depot Street BUFFALO, New York 14240 USA	
Screw Conveyor Corporation 700 Hoffman Street HAMMOND, Indiana 46320 USA	Screw conveyors, elevators.
Seedboro International Equipment Co. 1022 W. Jackson Boulevard CHICAGO, Illinois 60607 USA	Laboratory and conveying equipment.
Orville Simpson Co. 1230 Knowlton Street CINCINNATI, Ohio 45223 USA	Screens (Rotex)
Sprout Waldron & Co., Inc. MUNCY, Pennsylvania 17756 USA	Polishing brush, milling equipment, attrition mills.
SWECO 6111 E. Bandini Blvd. LOS ANGELES, California 90054 USA	Vibrating sieves.
Sweet Manufacturing Co. SPRINGFIELD, Ohio 45501 USA	Sprouting and accessories.
Triple S Dynamics (Sutton Steele) 1031 S. Haskell DALLAS, Texas 75223 USA	Gravity tables, stovers - graders.
Union Special Corporation 474 N. Franklin Street CHICAGO, Illinois 60610 USA	Sewing machines.

Universal Industries 1575 Big Rock Road West WATERLOO, Iowa 50701 USA		Elevators.
West Coast Alloys (Wescoloy) 600 - 16th Street OAKLAND, California 94612 USA	Mr. Harold Wilson	Steel hullers.

Part 2

Selected Bibliography of Rice Postharvest Publications

By A. P. Mossman[1]

[1] Western Regional Research Center, Agricultural Research, Science and Education Administration, U.S. Department of Agriculture, Albany, Calif. 94710.

INTRODUCTION

Over 400 publications were collected in support of the world survey of the current state-of-the-art in rice postharvest technology improvement conducted by the USDA/AID team in June through November 1978. Of these publications, over 200 have been included in this bibliography. Publications issued or obtained after the survey, as well as classic works issued some years past, and example works in closely related subject areas have also been added. A few bibliographies and some special serials (journals, newsletters, catalogues and annual reports) of which the postharvest worker should be aware, complete the list.

Selection of referenced articles has been dictated by the objectives of the survey project. Preference has been given to material actually collected during the survey. The documents supporting the survey report itself have been listed almost entirely except that brochures describing individual pieces of equipment issued by specific manufacturing companies or specific institutions have been omitted. While the information in such brochures is valuable, only the fact of their existence would be conveyed in a bibliography, and this fact can be conveyed as well in a few statements. It is obvious that each manufacturer has brochures available on request. Less obvious, however, is the fact that many research institutions also have similar brochures available describing in detail pieces of equipment which they have developed. Both of these sources should be investigated by the serious worker. Storage of rice was expressly excluded from the scope of the world survey project, therefore, very few publications involving storage appear here. Readers wishing to pursue the storage area can find a great deal of information through the more general bibliographies and would do well to contact Tropical Products Institute Storage Department which publishes a bimonthly Tropical Storage Abstracts (address on Page 177).

The survey emphasized hardware and process improvement encountered during threshing, drying, parboiling and milling of rice to reduce losses, especially at the village level. It is intended that the bibliography be an introduction to work in these areas. Most of the major institutions are represented, some more extensively than others. Many publications were listed for specific purposes. For example, the entire set of extension publications on rice of the Philippine National Grain Authority has been listed because it is believed that the development of such publications is as important as equipment development itself. A similar but less expensive series has been produced by the Rice Process Engineering Center, IIT, Kharagpur, India (listed by author). Although extension was an integral part of the survey project, extension publications would not usually be found in a bibliography. Likewise, the investigations on parboiling conducted at Central Food Technological Research Institute, Mysore, India, are presented in the publications of Bhattacharya as examples of what has been done, the direction their work is taking, and the journals which have been carrying their reports. The set is presented only as a starting place for the worker interested in current work in the area of parboiling.

It was felt that extensive listing of individual journal articles would expand and delay publication of the bibliography and so reduce its usefulness. Instead, greater emphasis has been put on identifying certain key serials,

especially annual reports of institutions, which, along with example publications as those mentioned above and a few particular books, should give the user immediate access to the somewhat hidden, sometimes colloquial literature presently available in the area of rice postharvest loss reduction.

Concerning the format of the bibliography, only three major sections have been presented:

1. Bibliographies and Information Services
2. Serials and Catalogs
3. Books and Articles

Each section is introduced by a brief description of the type of material contained there. Citations to most books and articles are arranged alphabetically by the surname of the first author. Publications without true authors are listed by publisher with names of editors and compilers given in parentheses. [Note: The code number following the citation (e.g., A-298) is our aquisition number or source code, helpful in handling the publications but having no other significance (A = Asia; W = world and United States; C = Central and South America; D = other areas; NAS = ref. 111; other codes = individual donors or sources)]

Citations have been made as brief as possible by the use of abbreviations. All abbreviations used as "author" have been listed in the abbreviation list along with some others in common usage. When the publisher is also the author, the publisher line is always abbreviated.

The Western Regional Research Center, USDA, which carried out the survey and compiled this bibliography is not a source of the publications listed. Some good general sources are listed in the first section of the bibliography. Authors or institutions often have individual copies for distribution and should be contacted. Unfortunately, some items are out of print. Perhaps the new emphasis on postharvest processing improvement which is evolving will cause excellent works to be reissued. (Some FAO classics are being reissued.)

Every effort has been made to release this bibliography quickly in order to provide the growing number of workers in rice loss reduction a timely and useful information base. Omissions of particularly important publications or information sources, and outright errors, should be brought to the attention of the compiler. Special thanks are due to the members of the AID study team and others who provided materials from their files, and to the many workers around the world who, in the spirit of open hospitality, provided time and information to the USDA/AID survey team, and who continually endeavor to exchange information in the important area of rice postharvest technology.

AID	U. S. Agency for International Development
AIT	Asian Institute of Technology, Bangkok
ALAD	Egypt; (uncertain)
AMA	Agricultural Mechanization in Asia
APO	Asian Productivity Organization
BULOG	Baden Urusan Logistik (food agency), Indonesia
CAB	Commonwealth Agricultural Bureau, Slough, U.K.
CATI	Coordenadoria de Assistencia Tecnica Integral, S. P., Brazil
Cedege	Comision de estudios para el Desarrollo de la cuenca de rio Guayas, Guayaquil, Ecuador
CFP	Comissao de financiamento da Producao, Porto Alegre, Brazil
CFTRI	Central Food Technological Research Institute, Mysore, India
CIAT	Colombia Centro Internacional de Agricultura Tropical, Cali
CIAT	Bolivia Centro de Investigacion Agricola Tropical, Santa Cruz
CIDA	Canadian International Development Agency
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brazil
EMBRATER	Empresa Brasileira de Assistencia Tecnica e Extensao Rural, Brazil
EPSA	Empresa Publica de Servicios Agropecuarios, Lima, Peru
ERS	Economic Research Service of the United States Department of Agriculture
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
FAE Report	Foreign Agricultural Economic Report, USDA
FAO	Food and Agricultural Organization of the United Nations
Fedearroz	Federacion Nacional de Arroceros, Colombia
FENCA	Federacion Nacional de Cooperativas Arroceras, Bolivia
FF	Ford Foundation
FIRDI	Food Industry Research and Development Institute, Taiwan
GIDA/ALC	(uncertain)
GOI	Government of India
IAM	Institute of Agricultural Machinery, Omiya, Japan
IATA	Instituto de Agroquimica y Technologia de Alimentos, Valencia, Spain
ICNND	Interdepartmental Committee on Nutrition for National Development, USA
IDRC	International Development Research Center, Ottawa, Canada
IIT	Colombia Instituto de Investigaciones Technologicas, Bogota
IIT	India Indian Institute of Technology
ILO	International Labor Organization (U. N.)
IRGA	Instituto Rio Grandense do Arroz (Rice Growers), Porto Alegre, Brazil
IRRI	International Rice Research Institute, Philippines
ITAL	Instituto Technologia de Alimentos, Campinas, Brazil
JCRR	Chinese-American Joint Commission on Rural Reconstruction, Taiwan
JRMA	Japanese Rice Millers Association, Tokyo, Japan
KIIT	Kharagpur Indian Institute of Technology (artificial name) see RPEC

KIST	Korean Institute of Science and Technology
KSU	Kansas State University, Manhattan, Kansas, USA
LSU	Louisiana State University, Baton Rouge, Louisiana, USA
MARDI	Malaysian Agricultural Research and Development Institute
MSU	Michigan State University, East Lansing, Michigan, USA
NAL	National Agricultural Library, USDA
NAS	National Academy of Sciences, Washington, DC, USA
NGA	National Grain Authority, Philippines
NRC	National Research Council of the NAS (NAS is used in all their citations
OAS	Organization of American States, (Organizacion de los Estados Americanos), Washington, DC
PMB	Paddy Marketing Board, Sri Lanka
PPRC	Paddy Processing Research Center, Tiruvarur, India
PRRM	Philippine Rural Reconstruction Movement
RF	Rockefeller Foundation
RPEC	Rice Processing Engineering Center, Indian Institute of Technology, Kharagpur, India
SEARCA	Southeast Asia Cooperative Postharvest Research and Development Program, Los Banos, Philippines
TPI	Tropical Products Institute, London, UK
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UPLB	University of the Philippines at Los Banos
USL/MSU	University of Sri Lanka/Michigan State University, Hawaii, USA
USDA	United States Department of Agriculture
USAID	AID - U. S. Agency for International Development
WARDA	West Africa Rice Development Association
WHO	World Health Organization, Geneva, Switzerland
World Bank	International Bank for Reconstruction and Development, including: International Development Association and International Finance Corporation
WRRC	Western Regional Research Center, U. S. Department of Agriculture

II

INFORMATION SERVICES AND BIBLIOGRAPHIES

A. Information Services

Some important sources of information are the activities in direct support of certain bibliographic collections. These information services (for want of a better name) are developing rapidly in the area of postharvest loss reduction and may prove to be as essential in this area as the bibliographies themselves.

001 FAO has now created a separate postharvest section in their AGRIS bibliography where relevant publications will be clearly identified. At present, only FAO publications can be obtained (through FAO outlets around the world) from this source. Questions can be directed to:

The Information and Documentation Service
Food and Agricultural Organization of
the United Nations
Via della Terme di Caracalla
00100 Rome, Italy

Each FAO member country has an outlet for FAO publications which accepts local currency. The United States outlet is:

Unipub
P.O. Box 433
Murray Hill Station
New York, New York 10016, USA
(Located at 345 Park Ave, South)

002 CAB of Slough, England, and TPI of London, are considering the possibility of jointly publishing abstracts in the field of postharvest losses. TPI already publishes Tropical Storage Abstracts (bimonthly and free) and CAB publishes many agricultural abstract journals including, Agricultural Engineering Abstracts and Rice Abstracts (listed in Section 2).

Tropical Products Institute
56-62 Gray's Inn Road
London WC1X 8LU, England

003 KSU has an extensive collection of publications on postharvest grain losses and can provide copies or microfiche of publications at cost. The publications obtained during the NAS study on postharvest food losses (451) have been turned over to KSU.

Postharvest Documentation Service
Kansas State University Library
Manhattan, Kansas 66506, USA

004 NAL-USDA received the computer tapes which were used in compiling the NAS bibliography (111) on food losses and is planning to use them as a special subset of the AGRICOLA automated retrieval system. Questions concerning access to the NAS bibliography through this method should be directed to:

Charles N. Beebe, Head
Automated Retrieval Service
National Agricultural Library
Beltsville, Maryland 20705, USA

Regretfully, the present rice postharvest loss bibliography has been compiled manually and there are no plans to build it into a separate subset.

005 IRRI has an extensive library devoted to rice. Although much of their collection is concerned with rice production, they have also many publications which deal with postharvest aspects. IRRI personnel compile special bibliographies from time to time in addition to their general international one. A unique and particularly valuable service is their translations into English of a great many rice publications. They have been compiled into a single bibliography as of 1976 (see Section B below). Questions regarding individual publications, copies of translations, or bibliographies themselves should be addressed to:

The Library and Documentation Center
The International Rice Research Institute
P.O. Box 933
Manila, Philippines

006 Other sources of information. It must be remembered that many of the service agencies maintain extensive collections and while these are not open to the public generally and bibliographies are not available, information in specific subject areas can sometimes be obtained by workers with a legitimate interest by contacting their counterparts within the agencies (e.g., World Bank, AID).

B. Bibliographies

The bibliographies are listed by institution with the name of the compiler in parenthesis. NAS after the citation indicates it was obtained from reference (111).

101 AACC (Houston, D. F., ed.) 1972
Rice Chemistry and Technology
AACC, 3340 Pilot Knob Road, St. Paul, MN 55121, USA
Note: This publication is listed here because the bibliographic material is extensive, current (until about 1970), and is separated by subject and discussed in the texts. A valuable source.
W-84

102 Bibliotheca Bogoriensis (1972)
Rice Bibliography of Indonesia 1842-1971
Bogor, Indonesia
EB

103 CAB 1975
Publications List 1975
CAB, Slough, England, U. K.
NAS P. 301

104 Commonwealth Secretariat (Stiles, D. E.) 1977
Postharvest losses of tropical grains with special reference to Africa; an interim bibliography
Comm. Sec., London, U. K.
NAS P. 304

105 FAO 1970
Food and Agricultural Industries: Annotated Bibliography
FAO, Rome, Italy
NAS P. 301

106 IDRC (Rolston, W. D.) 1974
Semi-annotated bibliography of research on postharvest technology for cereal grains and grain legumes in African countries north of the equator.
IDRC, Ottawa, Canada
NAS P. 303

107 IRRI 1971
Bibliography: Rice Milling and Processing (selected; mimeographed)
IRRI, Los Banos, Philippines
EB

108 IRRI (Malagayo-Alluri, F.) 1976
A bibliography of rice literature translations available in the IRRI Library and Documentation Center
IRRI, P.O. Box 933, Manila, Philippines
A-160

109 IRRI
International Bibliography of Rice Research 1951-1960 (published in 1963), yearly supplements 1961-1967 (at least)
IRRI, P.O. Box 933, Manila, Philippines
Scarecrow Press
Metuchen, New Jersey 08840, USA

110 IRRI (Ebron, L. Z.) 1977
A selected bibliography of agricultural mechanization in the Philippines
IRRI, P.O. Box 933, Manila, Philippines
A-333

111 NAS (Morris, R. F.) 1978
Postharvest food loss in developing countries. A bibliography.
NAS, Washington, D.C. 20418, USA
Note: This is a very valuable general food loss bibliography although a great majority of the citations deal with storage and pests. This is the NAS bibliography referred to in citations (3) and (4) above. Of particular interest are the lists of bibliographies, organizations, and periodicals (Chapter 14), as well as grain losses (Chapter 3) and rice (Chapter 5).
W-32

112 TPI (Adams, J. M.) 1977
A bibliography on postharvest losses in cereals and pulses with particular reference to tropical and subtropical countries.
TPI, London, U. K.
Note: It is reported that two separate bibliographies on losses have been published, one on storage losses (No. G-110) and a second on processing losses in grain systems (compiler and number unknown) issued in 1978.
NAS P. 300

113 TPI (Dendy, D. A. V., et al.) 1972
Composite Flour Technology Bibliography
TPI, London, U. K.
NAS P. 301

114 UPLB College of Agriculture
Abstract Bibliography of Rice
1926-1940
1941-1950
1951-1955
1956-1960
UPLB, Laguna, Philippines
WRRC Library

III

SERIALS AND CATALOGS

Included in this section are publications which retain the same name through successive different issues, such as annual reports, project reports and descriptions, catalogs of organizations (not of individual manufacturers), description brochures of organizations, lists, and a few periodicals. Example issues are cited only to show the connection between volume number and date.

201 AID
War on Hunger
AID, Department of State, Washington, DC, USA
Vol. 8(12), 1974
RMS

202 AID
AID Forum, an Exchange of Ideas and Thoughts about AID (published irregularly as an insert in Front Lines)
AID, Washington, D.C. 20523, USA

203 AIT (Soo-Jin Lee, ed.)
AIT Review
AIT, Bangkok, Thailand
Vol. 17(3), July 1978

204 AIT
Prospectus for 1978 (Information as in a catalogue)
AIT, Bangkok, Thailand
A-304

205 AIT, Division of Agriculture and Food Chemistry, 1978
Research Summary, January 1975 - August 1977
AIT, Bangkok, Thailand
A-304

206 AIT and CIDA
International Conferences at AIT Center, Bangkok, 1977-1980
AIT, Bangkok, Thailand
A-304

207 AMA (Kishida, Yoshisuke, ed.) 1978
Farm Machinery Industrial Research Corp. (Publisher)
Shin-Norin Building
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101, Japan
Vol. 9(2), Spring 1978
A-59

208 American Society of Agricultural Engineers (Rodda, ed.) 1975
ASAE Foreign Service Roster
ASAE, St. Joseph, Michigan 49085, USA
W-25

209 Anamalai University, 1978
Regional Center for Extension Service, Modernization of Rice Processing, Objectives
Anamalainagar, India
A-264

210 Anamalai University
Lists of Manufacturers of Mini Mills, Centrifugal Dehuskers, and Boilers.
Anamalainagar, India
A-275

211 APO
Introducing APO
Asian Productivity Organization
4-14 Akasaka 8-chome
Minato-ku, Tokyo, 107, Japan
A-61

212 Appropriate Technology Development Organization, Government of Pakistan (1978)
Seventh six-monthly Progress Report, July-December 1977
ATDO, Islambad, Pakistan
A-57

213 CAB 1979
Commonwealth Agricultural Bureau (British), London, U. K.
(1) Rice Abstracts (ca $80/year)
(2) Agricultural Engineering Abstracts (ca $90/year)
W-76

214 CIDA
Annual Review 1974-1975
CIDA, Ottawa, Canada
W-14

215 CFTRI, 197_ (probably 1977 or 1978)
Annual Report, January-December 1975
CFTRI, Mysore, India
A-55

216 CFTRI
Annual Report 1976 (received December 1978)
CFTRI, Mysore, India
A-298

217 Clarke, P. A., 1978
Rice Processing: A Check List of Commercially Available Machinery
TPI, London, U. K.
W-52

218 Cornell University (Metz, J. F., ed)
International Agricultural Development Bulletin (3/yr; free)
102 Roberts Hall, Cornell University, NY 14853, USA
NAS P. 306

219 EMBRAPA 1978
Pronapa 78, Programa Nacional de Pesquisa Agropecuaria (details of the National Agricultural Program 1978) (in Portuguese)
EMBRAPA, Brazilia, Brazil
C-51

220 EMBRAPA 1978
EMBRAPA ANO 5 (1977 activities)
EMBRAPA, Brazilia, Brazil
C-46

221 EMBRAPA 1977
Programa Nacional de Pesquisa de Arroz (Safra 1977/1978) (National program for rice research) (in Portuguese)
EMBRAPA, Goeania, Brazil
C-48

222 EPSA 1977
Memoria 75/76 Empresa Publica de Servicios Agropecuarios. Activities 1975/1976 of the Public Enterprise for Agribusiness Services (in Spanish)
EPSA, Lima, Peru
C-29

223 FAO
Ceres (FAO review on agriculture and development)
FAO, Rome, Italy
Vol. 12(1), January-February 1979
W-81

224 FAO 1979
Commodity Review and Outlook: 1977-1979
FAO, Rome, Italy
Note: No separate 1977-1978 was published due to the changeover to a fall cutoff date
WRRC

225 FAO 1973
International Directory of Agricultural Engineering Institutions
FAO, Rome, Italy

226 FAO 1977
International Rice Commission Newsletter
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TEN RECOMMENDED PUBLICATIONS

Since interest in rice postharvest loss reduction is growing, there are probably new workers unfamiliar with this area of endeavor who would welcome specific recommendations of publications with which to enter the field. The following list has been compiled for their advice without any presumption to rate the rice literature:

Citation number	Brief Title	Reasons for Recommendation
101 and 301	Rice Chemistry and Technology (Houston)	This AACC monograph is bibliographic in nature; provides easiest entrance into literature; all postharvest areas; emphasis on U. S. but also worldwide; research papers cited up to 1972.
275	Postharvest Quarterly (Teter)	Every serious worker should receive this SEARCA newsletter devoted to rice postharvest loss reduction; up-to-date information on research, books, projects, meetings, etc.
207	Agricultural Mechanization in Asia (Kishida)	A major outlet for rice postharvest articles by persons directly involved.
251	Rice Report (Barber)	Contains brief summaries of the majority of rice research projects currently under way in the entire world and addresses of workers and institutions.
451 and 111	Postharvest Food Losses in Developing Countries; Bibliography (NAS) (Morris)	Includes rice with storage and other sources of loss; bibliography excellent with several relevant sections, storage emphasized.
313	Rice Postharvest Technology (Araullo)	Overview of postharvest technology relating to developing countries; good diagrams; current replacement for out-of-print FAO monographs.
496	Quality Evaluation Studies of Foreign and Domestic Rices (Simpson)	USDA publication of results of quality tests applied to world commercial varieties, tests and rice characteristics up to 1965.

417	A Report on Rice Postproduction Technology Project (IRRI-UPLB)	The Bicol report; latest and most comprehensive study of rice postproduction including losses, methods, machinery; many related papers.
487	Rice Postharvest Losses in Developing Countries, Part 1 (Saunders)	The study to which this bibliography belongs.
405	Postharvest Grain Loss Assessment Methods (Harris)	Recent AACC publication of grain loss assessment methods; focus on standards and proper sampling; uniformity, social context.

In addition, particular attention should be paid to annual reports (e.g. IRRI Ag. Eng. Dept. Semiannual Progress Report; 257). Some older books have become classics because of their lucid descriptions (369, Efferson). The FAO books on rice mentioned previously (p. 173) as classics include: 390, 391 (Gariboldi); 346 (Borasio); and 484 (Ray). The ISO book is useful in comparing milling systems (415). Lastly, the bibliographies and other sources in Section I should be examined as time permits.

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